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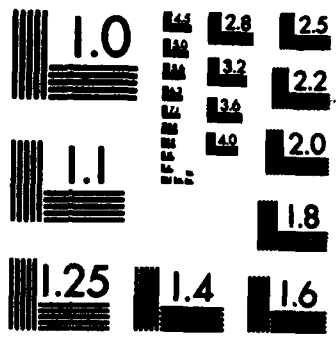

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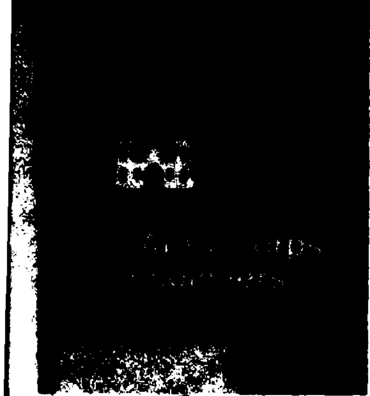

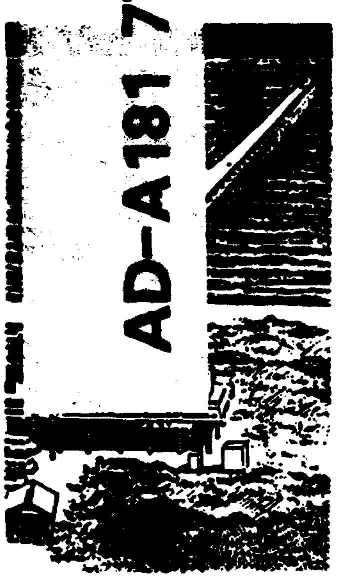

TECHNICAL REPORT CERC-87-7

TSUNAMI PREDICTIONS FOR THE COAST OF ALASKA KODIAK ISLAND TO KETCHIKAN

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by

Peter L. Crawford

Coastal Engineering Research Center

DEPARTMENT OF THE ARMY
Waterways Experiment Station, Corps of Engineers
PO Box 631, Vicksburg, Mississippi 39180-0631

April 1987

Final Report

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The 100- and 500-year combined tsunami and tide elevations were predicted at sites along the coast of Alaska between Kodiak Island and Ketchikan. Lack of historical data at most sites necessitated the generation of a synthetic record of tsunami activity in the Gulf of Alaska. The geophysical and tectonic setting of the Gulf were used to synthesize a record of tsunamigenic, tectonic deformations of the seafloor. A numerical model was used to simulate the tsunamis resulting from each deformation. Numerical simulations of the 1964 Alaskan tsunami were made and compared with historical tide gage recordings.

Historical data of tsunami activity along the entire Aleutian trench were used to assign probability of occurrence to each tsunami in the synthetic record. A numerical procedure was used to combine the effects of astronomical tides and tsunamis and to produce the 100- and 500-year combined tsunami and tide elevations.

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PREFACE

The study described herein was authorized by the Office, Chief of Engineers, US Army Corps of Engineers, in a letter dated 30 April 1985 and was performed for the Federal Insurance Administration (FIA), Federal Emergency Management Agency, under Interagency Agreement EMW-85-E-1822, Project Order No. 1, Amendment No. 14. The FIA Technical Monitor was Dr. Frank Tsai.

The investigation was conducted from May 1985 to July 1986 by personnel of the Research Division of the Coastal Engineering Research Center (CERC), US Army Engineer Waterways Experiment Station (WES). Mr. Peter L. Crawford, Coastal Oceanography Branch (COB) was the Principal Investigator of the study and prepared this report under direct supervision of Dr. Edward F. Thompson, Chief, COB, and Mr. H. Lee Butler, Chief, Research Division, CERC; and under general supervision of Dr. James R. Houston and Mr. Charles C. Calhoun, Jr., Chief and Assistant Chief, CERC, respectively.

This report was edited by Ms. Shirley A. J. Hanshaw, Information Products Division, Information Technology Laboratory, WES.

During publication of this report, COL Dwayne G. Lee, CE, was Commander and Director of WES. Dr. Robert W. Whalin was Technical Director.

CONTENTS

CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
degrees (angle)	0.01745329	radians
feet	0.3048	metres
miles (US statute)	1.609347	kilometres
miles (US nautical) per hour	1.852	kilometres per hour

TSUNAMI PREDICTIONS FOR THE COAST OF ALASKA
KODIAK ISLAND TO KETCHIKAN

PART I: INTRODUCTION

Background

1. Of all water waves that occur in nature, one of the most destructive is the tsunami. The term "tsunami," originating from the Japanese words "tsu" (harbor) and "nami" (wave), is used to describe sea waves of seismic origin. When they occur along the seabed, tectonic earthquakes (i.e., earthquakes that cause a deformation of the earth's crust) appear to be the principal seismic mechanism responsible for the generation of tsunamis. Coastal and submarine landslides and volcanic eruptions also have triggered tsunamis.

2. Tsunamis are principally generated by undersea earthquakes of magnitude greater than 6.5 on the Richter scale with focal depths less than 30 miles.* They are very long-period waves (5 min to several hours) of low height (a few feet or less) when traversing water of oceanic depth. Consequently, they are not discernible in the deep ocean and go unnoticed by ships. Tsunamis travel at the shallow-water wave celerity equal to the square root of acceleration from gravity times water depth even in the deepest oceans because of their very long wavelengths. This speed of propagation can be in excess of 500 mph in the deep ocean.

3. When tsunamis approach a coastal region where the water depth decreases rapidly, wave refraction, shoaling, and bay or harbor resonance may result in significantly increased wave heights. The great periods and wavelengths of tsunamis preclude their dissipating energy as a breaking surf; instead, they are apt to appear as rapidly rising water levels and only occasionally as bores.

4. Over 500 tsunamis have been reported within recorded history, and virtually all of them have occurred in the Pacific Basin. Most tsunamis are associated with earthquakes, and most seismic activity beneath the oceans is concentrated in the narrow fault zones adjacent to the great oceanic trench

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* A table of factors for converting non-SI units of measurement to SI (metric) units is presented on page 3.

systems which are predominantly confined to the Pacific Ocean.

5. The loss of life and destruction of property resulting from tsunamis have been immense. The Great Hoei Tokaido-Nankaido tsunami of Japan killed 30,000 people in 1707. In 1868, the Great Peru tsunami caused 25,000 deaths and carried the frigate USS Waterlee 1,300 ft inland. The Great Meiji Sanriku tsunami of 1896 killed 27,122 persons in Japan and washed away over 10,000 houses.

6. In recent times, three tsunamis have caused major destruction in areas of the United States. The Great Aleutian tsunami of 1946 killed 173 persons in Hawaii, where heights as great as 55 ft were recorded. The 1960 Chilean tsunami killed 330 people in Chile, 61 in Hawaii, and 199 in distant Japan. The most recent major tsunami to affect the United States, the 1964 Alaskan tsunami, killed 107 people in Alaska, 4 in Oregon, and 11 in Crescent City, California, and caused over 100 million dollars in damage on the west coast of North America.

Purpose of Study

7. The purpose of this study was to establish 100- and 500-year combined tsunami and tide elevations for the coast of Alaska from (and including) Kodiak Island to Ketchikan. The study area is shown in Figure 1. The Alexander Archipelago beyond the open coast is not included in the study area. Previous reports by Houston and Garcia (1978) and Houston (1980) established the 100- and 500-year elevations for the west coast of the continental United States. The 100- and 500-year elevations are required by the Federal Insurance Administration of the Federal Emergency Management Agency (FEMA) for use in flood insurance rate determinations.

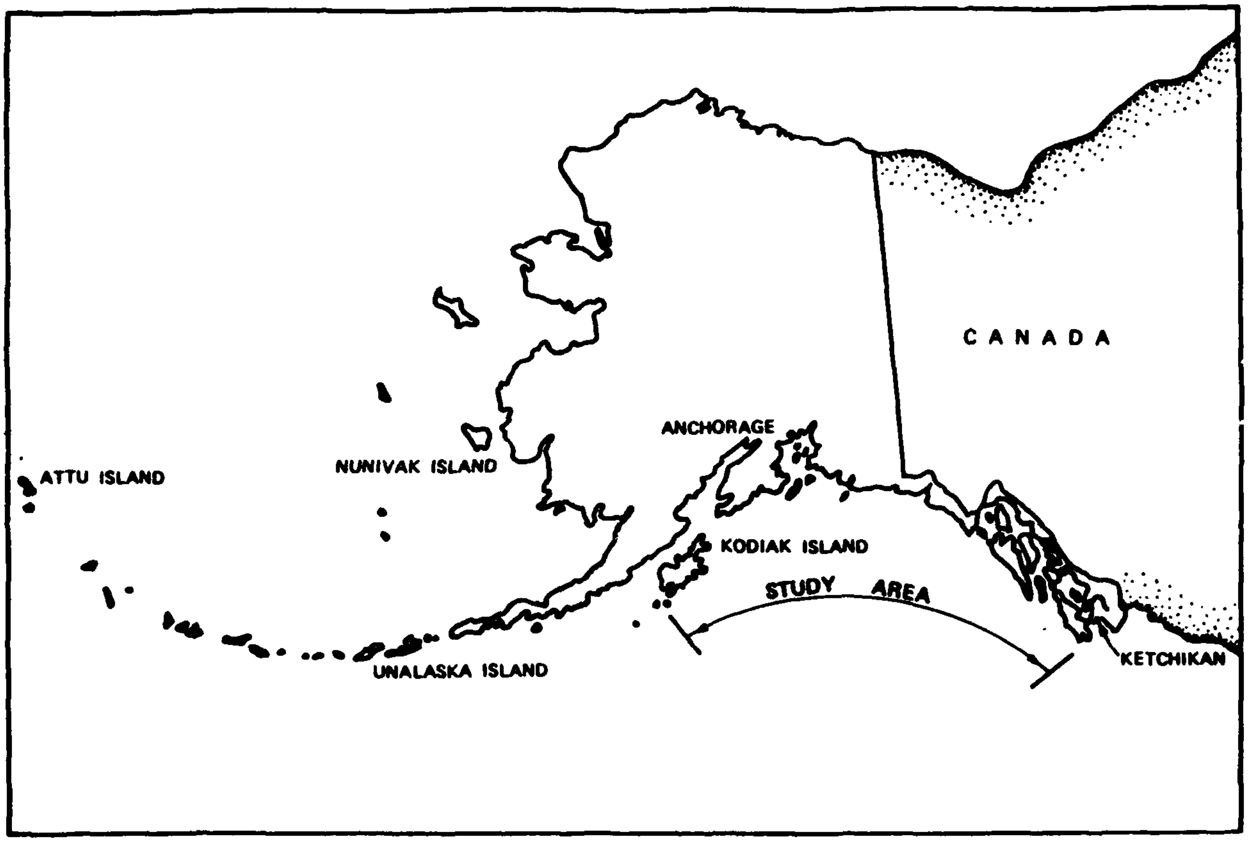

Figure 1. Study area

PART II: METHODS FOR ELEVATION PREDICTION

8. FEMA requires the 100- and 500-year combined tsunami and tide elevations for locations along the coast of Alaska bordering the Gulf of Alaska. Because of the isolation of the area, there are no historical data of tsunami occurrence at most of these locations. At the few locations where tsunami occurrence has been documented, the unreliability of the data and the brevity of the record made it impossible to perform the required frequency analyses. Therefore, it was necessary to synthesize a record of tsunami activity throughout the study area and to assign a probability of occurrence to each tsunami in the synthetic record.

9. The method for determining the 100- and 500-year combined tsunami and tide elevations is summarized in this paragraph and discussed in detail in the following sections. First, a record of tectonic deformations of the seabed was synthesized. A numerical model was then used to simulate propagation of the tsunami caused by each of the synthetic seabed deformations. The numerical model produced tsunami elevation time-histories at numerical gage locations throughout the study area. Model results were used to establish the intensity of each tsunami, and probability of occurrence was assigned to each tsunami according to its intensity. Finally, a numerical procedure was used to combine the effects of astronomical tides and tsunamis to determine the 100- and 500-year combined tsunami and tide elevations at the numerical gage locations.

Synthetic Record of Tectonic Deformations of the Seabed

10. To synthesize a record of tectonic deformations of the seabed, three characteristics of each deformation must be defined: the shape of the rupture zone (defined here as the area of the ground that is deformed by an earthquake), the distribution of uplift over the rupture zone, and the location of the rupture zone.

Rupture zone locations

11. Tsunamis of distant origin are not considered a threat to the study area. Furthermore, large tsunamis have not historically originated in the eastern Gulf of Alaska because this region borders an area of strike-slip faulting along the border of the North American and Pacific tectonic plates.

It is well known that the faulting of most tsunamigenic earthquakes is of the dip-slip type and that very few large tsunamis have been generated by strike-slip faulting. Therefore, the eastern Gulf of Alaska was not considered as a tsunamigenic region.

12. In the western Gulf of Alaska, the Aleutian trench-arc system represents a subduction zone where the Pacific plate sinks beneath the North American plate. Faulting along the trench is believed to be predominantly of the dip-slip type. That the trench has historically been a region of high seismic and tsunamigenic activity is well documented. In particular, in a catalogue of Alaskan tsunamis, Cox, Pararas-Carayannis, and Calebaugh (1976) list at least 10 large tsunamis that have been generated along the Aleutian trench since 1870. As discussed in the remainder of this subsection, the eastern end of the trench was considered to be the only tsunamigenic region which could produce tsunamis capable of causing great enough runup in the study area to affect the 100- and 500-year combined tsunami and tide elevations.

13. Rupture zones of tsunamigenic earthquakes along deep sea trenches at Pacific margins are generally elliptically shaped with the major axis of the ellipse parallel to the trench. The majority of the energy of a large tsunami will propagate from the source in a direction normal to the major axis of the ellipse. If H_a* is the wave height emitted in the direction parallel to the major axis of length a by a tsunami with an elliptically shaped rupture zone and H_b is the wave height emitted in the direction parallel to the minor generation axis of length b, then experimental research of tsunami generation has shown that $H_b/H_a \approx a/b$ (Hatori 1963). For a large tsunami H_b can be as much as five or six times greater than H_a. This fact and consideration of the alignment of the Aleutian trench relative to the study area (Figure 2) indicated that only tsunamis originating at the eastern end of the trench would cause significant runup in the study area. Furthermore, geophysical evidence (discussed in the following paragraph) permitted all rupture zones in the synthetic record to be placed coincident with that of the 1964 great Alaskan earthquake.

14. Davies, et al. (1981) state that the Alaska-Aleutian portion of the North American plate consists of tectonic blocks which are delimited along the

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* For convenience, symbols and abbreviations are listed in the Notation (Appendix A).

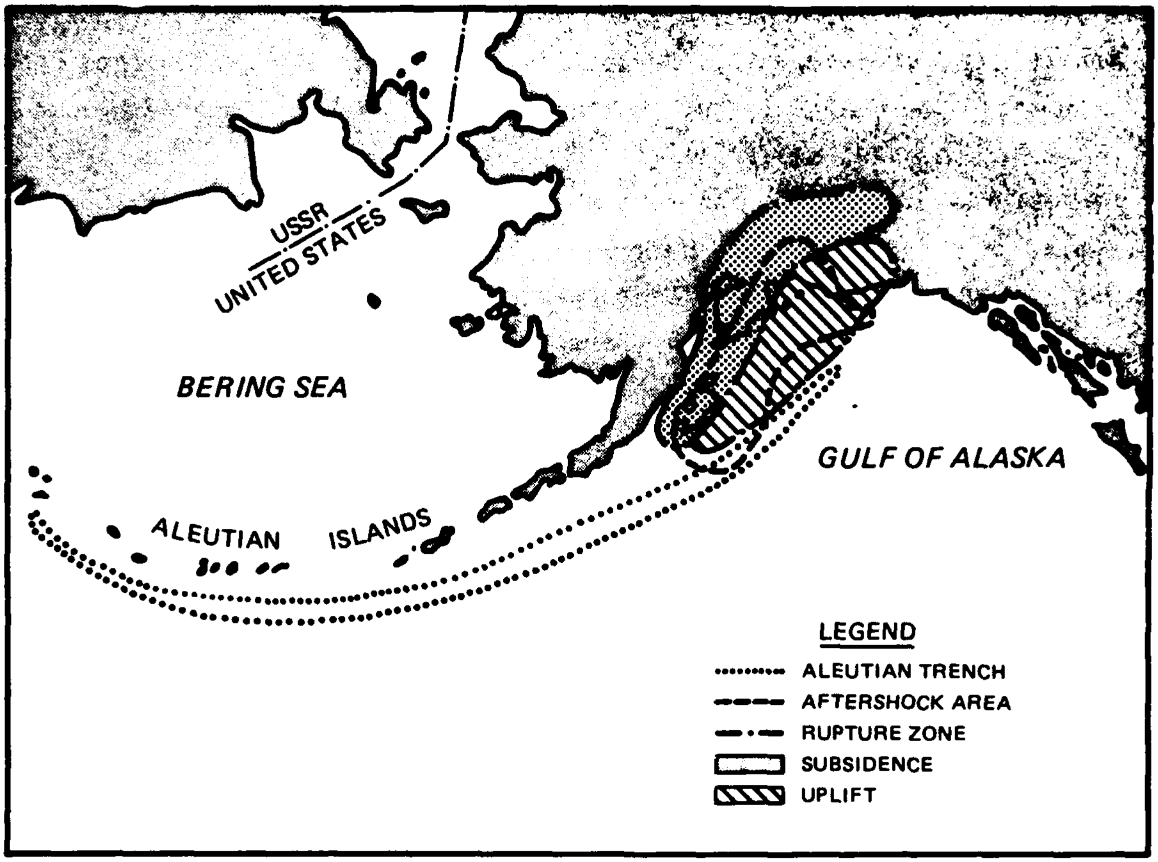

Figure 2. Aftershock area and rupture zone of the 1964 great Alaskan earthquake

trench by transverse structural features. The blocks are nearly mechanically independent of adjacent blocks. The along-trench limits of each block correspond to the along-trench limits of aftershock areas of major historical earthquakes. The only block located such that it was of concern to the study area is that associated with the 1964 great Alaskan earthquake. (The majority of the energy of tsunamis generated by faulting of the other blocks would be propagated away from the study area.) Figure 2 shows the rupture zone and the limits of the aftershock area of this earthquake. Since the rupture zone of the 1964 earthquake covered nearly the entire aftershock area of that earthquake, all rupture zones in the synthetic record of seabed deformations were located coincident with that of the 1964 earthquake.

Rupture zone shape and distribution of uplift

15. The 1964 Alaskan earthquake is one of only two (the other was the 1960 Chilean earthquake) for which detailed measurements of the deformation

of the seabed have been made. In order to define the shape of the rupture zone and the uplift distribution of each deformation in the synthesized record, it was assumed that the rupture zone and uplift of the 1964 event were appropriate to use as a model for all proposed deformations. A record of tectonic deformations of the seabed was synthesized by specifying that each deformation in the record would have not only the same location but also the same rupture zone shape and uplift distribution (but different magnitude of uplift) as that caused by the 1964 Alaskan earthquake.

Numerical Model

16. The linear nondispersive shallow-water equations used to model the propagation of tsunamis are

$$\frac{\partial u}{\partial t} = -\frac{g}{R}\frac{\partial \eta}{\partial \theta} + fv - \frac{ku}{d} \tag{1}$$

$$\frac{\partial v}{\partial t} = -\frac{g}{R \sin\theta}\frac{\partial \eta}{\partial \phi} - fu - \frac{kv}{d} \tag{2}$$

$$\frac{\partial \eta}{\partial t} = -\frac{1}{R \sin\theta}\left\{\frac{\partial\left[(d+\eta)\, u \sin\theta\right]}{\partial \theta} + \frac{\partial\left[(d+\eta)v\right]}{\partial \phi}\right\} \tag{3}$$

where

- u,v = vertically averaged velocity components in the θ and ϕ directions
- t = time
- g = acceleration because of gravity
- R = radius of the Earth
- η = displacement of the water surface from the still-water level
- θ = latitude measured from 0 at the North Pole
- f = Coriolis parameter
- k = linear friction coefficient
- d = still-water depth
- ϕ = longitude measured east from Greenwich

17. Kowalik and Murty (1984) used these equations to study the tsunami propagation resulting from a predicted major earthquake in the Shumagin seismic gap area of the Aleutian Island chain. These or similar linear

nondispersive equations are commonly used to study tsunami propagation in the deep ocean.

18. The validity of these equations over the continental shelf may be questioned. Several investigators, however, find that their use is justified. Tuck (1979) found that "...linear long-wave equations are adequate to describe most of the tsunami generation, propagation, and reception processes." In studying tsunami propagation from the deep ocean to the nearshore regions, Goring (1978) concluded that "... because of the small relative height of tsunamis and their large lengths relative to the lengths of the continental slope, the propagation of tsunamis from the deep ocean to the continental shelf-break [sic] and for some distance onto the shelf will be predicted as well by the linear nondispersive theory as by the nonlinear theories."

19. Studies of the behavior of tsunamis over real bathymetry have indicated also that linear nondispersive equations are appropriate. Numerical studies by Houston (1978) have shown that linear nondispersive equations govern tsunami generation, propagation over the deep ocean, and interaction with the Hawaiian Islands. Houston (1980) found from numerical experiments that nonlinear advection terms had no significant effect on tsunamis propagated from the deep ocean to the shoreline in the southern California region. Alexeev et al. (1978) studied the generation and propagation of tsunamis in the region of the South Kuril Islands. They obtained nearly identical tsunami elevation time-histories at Kunashir Island using linear and nonlinear equations. The evidence suggests that the equations used in this study accurately modeled tsunami propagation in the Gulf of Alaska.

20. The initial condition used in the model was that the initial deformation of the water surface was the same as that of the permanent vertical displacement caused by the tectonic deformation of the seabed, except that sharp irregularities in the profile were smoothed out. The justification for the smoothing is given by Wilson (1969). This type of initial condition has been used by many investigators, including Houston and Garcia (1974), Brandsma, Divoky, and Hwang (1978), and Aida (1981).

21. The model equations were solved by a system of finite difference approximations. The finite difference scheme was similar to that presented by Reid and Bodine (1968). The outline of the grid used for the computations is shown in Figure 3. Spacing between grid points was 0.065 deg along parallels and 0.04 deg along meridians. The along-meridian spacing corresponds to an

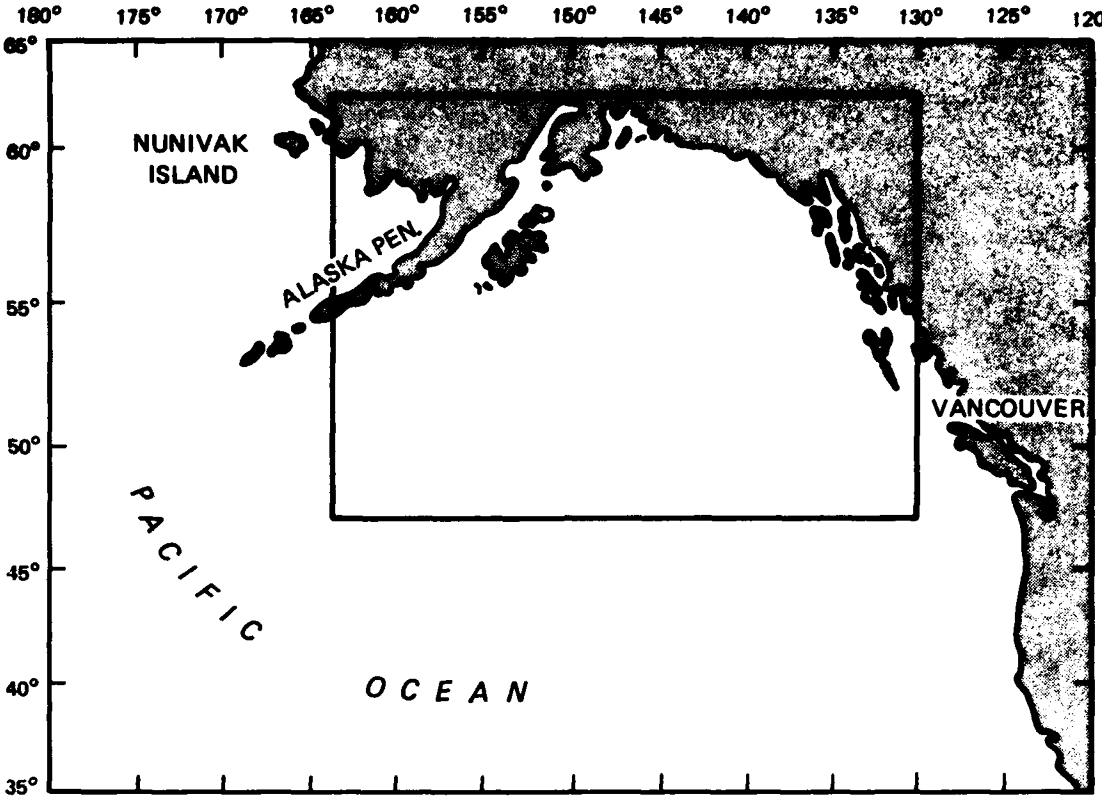

Figure 3. Boundary of the finite difference grid

arclength of 2.77 miles. The along-parallel spacing varies with latitude and takes on a minimum arclength of 2.18 miles along the northern edge of the grid and a maximum arclength of 3.06 miles along the southern edge of the grid. The grid spacing used provided resolution of such topographic features as Resurrection Bay, Port Valdez, and Sitka Sound.

22. The model was calibrated by adjusting the friction coefficient k in order to adequately reproduce the tide gage recordings made at Sitka and Yakutat during the Alaskan tsunami of March 1964. The comparisons of the actual tide gage recordings (with the astronomical tide subtracted out) and the computed tsunami elevation time-histories for Sitka and Yakutat are shown in Figures 4 and 5, respectively. The main tsunami wave, having a period of aproximately 1.7 hr, is modeled quite well. The higher frequency oscillations in the actual tide gage records represent the effects of the local scattering of the tsunami wave. They may also represent some locally generated waves caused, for example, by submarine landslides induced by the earthquake.

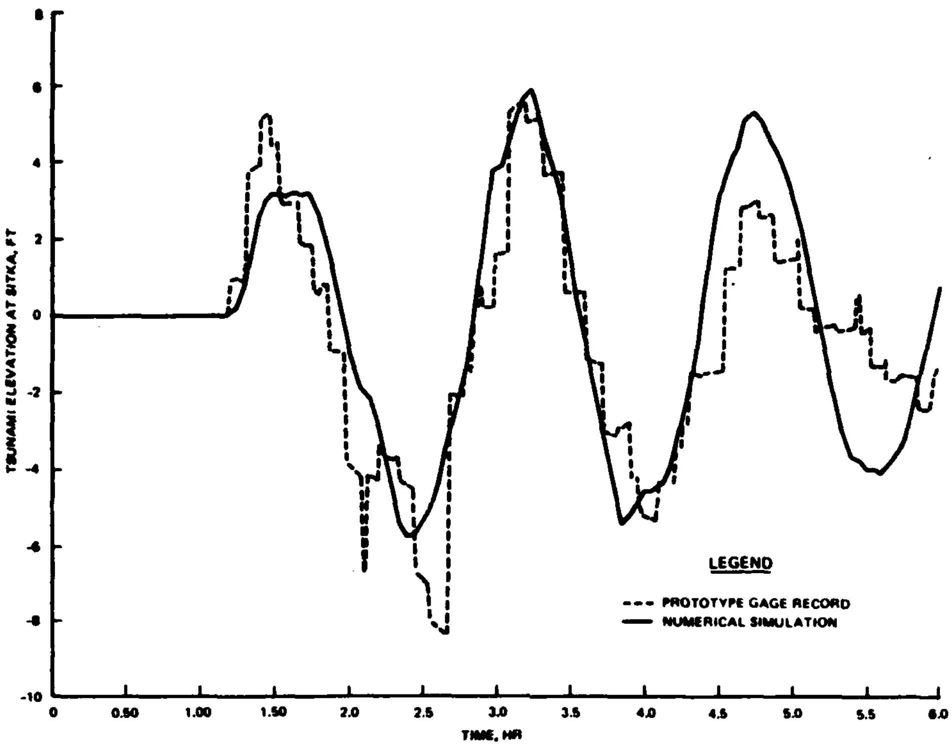

Figure 4. 1964 Alaskan tsunami at Sitka, Alaska

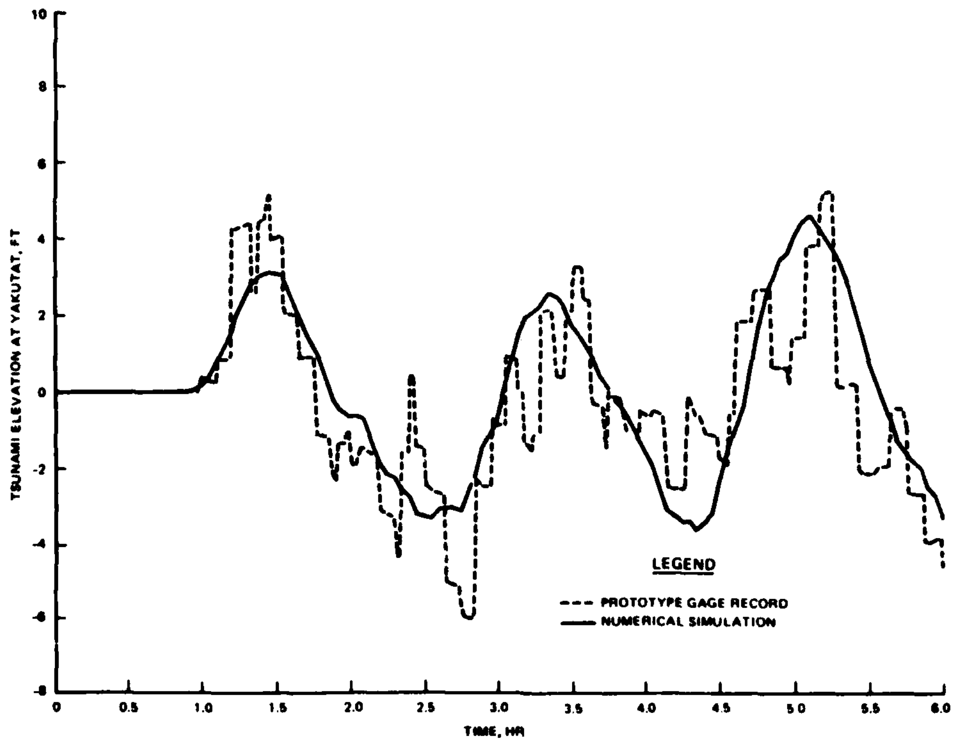

Figure 5. 1964 Alaskan tsunami at Yakutat, Alaska

Tsunami Occurrence Probabilities

23. Historical data on tsunami generation must be the basis for an analysis that considers the probability of tsunami generation along the Aleutian Trench. A satisfactory correlation between earthquake magnitude and tsunami intensity has never been demonstrated. Not all large earthquakes occurring in the ocean even generate noticeable tsunamis. Furthermore, earthquake parameters of importance to tsunami generation, such as focal depth and vertical ground motion, have been measured only for earthquakes occurring in recent years. Therefore, data on earthquake occurrence cannot be used to determine occurrence probabilities of tsunamis. Historical data of tsunami occurrence generation regions must be used to determine these probabilities.

24. The concept of tsunami intensity was put forth by Soloviev (1970). He defined intensity as

$$i = \log_2 \left(\sqrt{2}\, H_{avg} \right) \tag{4}$$

where H_{avg} is the average maximum runup (in metres) observed along the coastline adjacent to the source region.

25. The standard assumption in both earthquake and tsunami analysis is that the logarithm of the probability of occurrence of an event is linearly related to its intensity. In the Aleutian Trench area, only large tsunamis occurring since 1788 have been reliably documented. Assuming an exponential coefficient of -0.71 for this trench area (Soloviev (1970) found this coefficient to be the mean value for areas of the Pacific with the most data on tsunamis) and using only the reliable data, Houston (1978) established the following relation for the Aleutian Trench area:

$$n(i) = 0.113\, e^{-0.71i} \tag{5}$$

where $n(i)$ is the probability that, in any given year, a tsunami having intensity i will occur somewhere along the Aleutian Trench. Equation 5 gives the ordinates of a histogram where intensities have been grouped in increments of one-half the unit intensity.

26. Equation 5 was derived by considering tsunamis which occurred anywhere along the Aleutian Trench. As discussed in Part II, only tsunamis

generated at the eastern end of the trench were considered important. Since tsunami generation is equally probable anywhere along the trench, the probability of generation at the eastern end of the trench was one-fifth the value predicted by Equation 5. (The eastern end of the trench is approximately one-fifth the total length of the trench.)

Use of Numerical Model

27. Using the vertical permanent uplift of the seabed presented by Plafker (1969), the numerical model was used to simulate the behavior of the 1964 Alaskan tsunami. Tsunami elevation time-histories predicted by the model were saved at numerical gage locations throughout the study area. The model results indicated the average runup adjacent to the source region of the 1964 tsunami to be 11.8 ft and its intensity to be 2.4.

28. The uplift distribution over the rupture zone of the 1964 Alaskan earthquake was used to establish a record of tectonic deformations of the seabed. Each uplift distribution was given the same shape but a different magnitude from that of the 1964 event. To synthesize the record of uplifts in accordance with the linear model equations, the ratio of the uplift heights of two different tsunamis was equal to the ratio of the average runup heights on the coast. This ratio is equal to $2^{(i_1-i_2)}$ for tsunamis with intensities i_1 and i_2 . Since the uplift heights and intensities were determined for the 1964 event, a record of uplift heights was established by allowing tsunami intensity to vary from -1.0 to 4.5 (incrementing by 0.5) and then calculating the associated uplift heights. The lower limit was chosen because numerical experiments indicated tsunamis having lower intensities did not affect the 100- and 500-year combined tsunami and tide elevations. The upper limit was chosen because the largest tsunami intensity ever reported was less than 4.5.

29. The numerical model was used to simulate propagation of the tsunami caused by each of the 12 uplifts. For each of the 12 simulated tsunamis, 24 hr of tsunami elevation time-history were saved at numerical gage locations throughout the study area. The intensity of each of the 12 tsunamis was calculated using the model results and Equation 4. The calculated intensity was then used to assign probability using one-fifth the value found using Equation 5.

Effect of Astronomical Tides

30. The maximum still-water elevation produced during tsunami activity is the result of a superposition of tsunami and astronomical tide. Therefore, the statistical effect of astronomical tides on total tsunami runup must be included in the predictive scheme presented in this report. Since the wave forms calculated by the model did not have a simple form (e.g., sinusoidal), the statistical effect of the astronomical tide on tsunami runup had to be determined through a numerical approach.

31. A computer program was developed to predict time-histories of the astronomical tides throughout the study area. The program was based upon the harmonic analysis methods used in the past by the National Ocean Survey (NOS) for mechanical tide-predicting machines (Schureman 1971). Tidal constants available from NOS were used as input to the computer program. A year of tidal elevations was then predicted for grid locations in the study area. The year 1964 was selected because all the major tidal components for tides in Alaska had a node factor of approximately 1.00 during this year, thus making it an average year. The node factor is associated with the revolution of the moon's node and has an 18.6-year cycle. Since a tsunami can arrive at any time during this 18.6-year period (arrival at a low of the node factor being equally as likely as an arrival at a high), the statistical effect of the temporally varying node factor on the predicted runup elevations is shown by Houston (1980) to be very small.

32. The tidal time-histories calculated at each numerical gage location were subdivided into 30-min segments. Each of the twelve 24-hr wave forms was allowed to arrive at the beginning of each of these 30-min segments and then superimposed upon the astronomical tide for the 24-hr period. The maximum combined tsunami and astronomical tide elevation over the 24-hr period was determined for tsunami wave forms arriving during each of these 30-min starting times. Each of these maximum elevations had an associated probability equal to the probability that a certain intensity tsunami would be generated during a particular 30-min period of the year.

33. The many maximum elevations with associated probabilities were used to determine exceedance frequency distributions of combined tsunami and astronomical tide elevations. The maximum elevations were ordered and frequencies summed, starting with the largest elevations, until a desired frequency was

obtained. The elevation encountered when the summed frequency reached a desired value F was the elevation that is equaled or exceeded with an average frequency of once every 1/F years. Thus, when the summed frequencies reached the value 0.01, the elevation associated with the last frequency summed was the 100-year elevation.

PART III: EXPLANATION OF RESULTS

34. The 100- and 500-year combined tsunami and tide elevations were predicted at 1,249 sites in the study area. The latitude and longitude of each site and the 100- and 500-year elevations (in feet) are listed in Table 1. The elevations in this report are referenced to the local mean sea level (msl) datum. The locations of the sites are shown in Plates 1-77.

35. At some locations an apparently contradictory result is found: the predicted 100-year combined tsunami and tide elevation is less than the maximum tide. At Anchorage, for example, the predicted 100-year elevation is 15.7 ft, and the maximum computed tide occurring in 1964 is 16.7 ft. This result is correct, however, since the predicted combined tsunami and tide elevations are determined given the occurrence of a tsunami. The combined elevation occurrence probabilities are dominated by the low probability of tsunami occurrence. The arrival of a tsunami at a time during the year when it will result in a greater water surface elevation than the maximum for the year is an event with a return period greater than 100 years. This kind of result indicates that severe tsunami damage is not likely at locations, such as Anchorage, where tsunami amplitudes are small compared to the tide range.

Shoreline Elevation Versus Runup Elevation

36. The tsunami elevations presented in Table 1 are elevations at the shoreline. They were determined by a finite difference solution to the linear shallow-water equations. Only tsunamis resulting from the tectonic-scale permanent vertical deformation of the seafloor were considered. Local phenomena such as seafloor slumping or small-scale local features of the faulting were not considered. The steepness of the tsunami associated with the tectonic-scale faulting is so small that it precludes the possibility of the tsunami breaking as it moves onshore. Hence, except as discussed in the remainder of this section, elevations presented in this report also can be considered runup elevations.

37. Three situations in which the runup elevation is not equal to the shoreline elevation are:

a. Where the tsunami intrudes into a river and creates a bore.

b. Where dunes prevent flooding except through inlets.

c. Where the land is extremely flat and inland flooding is extensive.

The runup elevation determinations for these cases can be made as discussed in paragraphs 38 and 39.

38. The simulation of tsunami penetration into a river, including the prediction of bore formation, can be made using the method of characteristics (Henderson 1966). Horiguchi (1966) presents a scheme, based on the method of characteristics, for computing tsunami penetration into bays and river branches including prediction of bore formation.

39. Where dunes prevent flooding, except through inlets or where the land is extremely flat and inland flooding is extensive, a land flooding numerical model can be used to determine runup. A model of this type which incorporates the effects of bottom friction and irregular topography has been developed by Houston and Butler (1979).

Runup Determinations Between Listed Sites

40. The tsunami wavelengths are so great compared to the length scale of irregularities in the coastline that linear interpolation may be used to determine 100- and 500-year elevations at locations between the sites shown in Plates 1-77.

PART IV: CONCLUSIONS AND RECOMMENDATIONS

Conclusions

41. To determine tsunami elevations, a record of local tectonic displacements of the seabed was synthesized. In previous studies, Houston and Garcia (1978) and Houston (1980) considered only distantly generated tsunamis. These authors concluded that only the gross shape of the ground deformation was necessary to determine tsunami elevations at distant locations. Hence, they synthesized a record of tectonically reasonable displacements of the seabed knowing that the exact shape of each deformation was unimportant. The situation was not as simple in this study since all tsunamis were locally generated.

42. It is obvious that, in the near field, tsunami elevations will depend on the shape of the seabed deformations. Still, the method used required that a model deformation be defined. Hence, it was necessary to assume that the standard deformation employed would result in the same 100- and 500-year combined tsunami and tide elevations as would have resulted if actual historical sources had been employed. In light of the fact that tectonic displacements are known for only two submarine earthquakes--the 1960 Chilean earthquake and the 1964 Alaskan earthquake--the assumption is not only reasonable (as discussed in Part II) but also necessary.

43. The numerical model used in this study accurately simulated tsunami propagation in the open ocean of the Gulf of Alaska, on the narrow shelf of the eastern Gulf of Alaska, and in Prince William Sound. In Cook Inlet the water is sufficiently shallow such that the adequacy of the linear nondispersive model equations may be questioned. Tsunami heights in the inlet, however, are fairly small since Kodiak Island, the Barren Islands, and Kenai Peninsula shelter the inlet from the major tsunami generating region. Hence, the model is considered to be adequate in Cook Inlet also.

Recommendations

44. The elevations predicted in this report are at the shoreline but can be assumed to equal runup elevations for most of the study area. There are locations where time-dependent effects (e.g., lack of sufficient time to

completely flood extensive low-lying or estuarine areas) or two-dimensional effects (e.g., flow divergence or convergence) cause tsunami runup elevations to differ from elevations at the shoreline. It is recommended that inundation limits for these areas be determined using a numerical model developed at the US Army Engineer Waterways Experiment Station (Houston and Butler 1979). This model is capable of handling land flooding for bays, harbors, developed areas such as cities, large low-lying areas, sand-dune protected areas, and other areas where there are topographical, roughness, or coastline variations. There are also locations at river mouths where the formation of a bore will affect the runup elevations. This problem can be efficiently treated using the method of characteristics.

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Table 1

Gage Locations and 100- and 500-Year

Combined Tsunami and Tide Elevations

Gage Number	Longitude deg	Longitude min	Longitude sec	Latitude deg	Latitude min	Latitude sec	100-Year Elevation ft	500-Year Elevation ft
1	154	55	57	57	59	46	10.2	13.5
2	154	51	20	58	0	10	10.2	13.1
3	154	47	50	57	58	34	10.2	13.1
4	154	43	31	58	0	13	10.2	12.8
5	154	37	10	58	1	2	10.2	12.5
6	154	33	21	58	1	13	10.2	12.5
7	154	29	27	58	2	16	10.2	14.1
8	154	26	31	58	5	9	10.2	14.1
9	154	19	34	58	4	14	10.2	13.8
10	154	15	35	58	6	50	10.2	13.5
11	154	12	24	58	7	27	10.2	13.5
12	154	9	38	58	10	58	10.2	14.4
13	154	8	29	58	13	8	10.5	15.7
14	154	6	4	58	15	53	10.5	17.4
15	154	10	34	58	18	24	11.8	24.9
16	154	18	24	58	16	47	12.1	25.6
17	154	15	10	58	18	23	12.5	26.6
18	154	9	18	58	19	21	11.5	23.3
19	154	3	55	58	20	30	10.8	20.3
20	153	59	45	58	21	50	10.5	18.0
21	154	2	49	58	24	5	10.8	19.4
22	154	2	36	58	28	25	11.2	20.3
23	153	56	60	58	28	31	10.8	19.4
24	153	54	12	58	30	5	10.8	19.7
25	153	54	22	58	32	9	11.2	20.7
26	153	53	41	58	35	2	11.5	22.6
27	153	49	9	58	35	43	11.2	21.0
28	153	45	41	58	35	18	10.8	19.7
29	153	41	28	58	35	43	10.8	18.7
30	153	37	17	58	36	54	10.5	17.7
31	153	35	4	58	37	40	10.5	16.1
32	153	33	40	58	39	40	10.5	17.4
33	153	29	35	58	41	16	10.8	19.4
34	153	25	4	58	42	31	10.8	18.4
35	153	22	39	58	44	47	10.5	15.1
36	153	22	4	58	46	36	10.5	15.7
37	153	17	1	58	49	14	10.5	16.7
38	153	19	22	58	52	42	10.5	17.4
39	153	19	8	58	54	18	10.5	17.1
40	153	23	13	58	55	44	10.5	16.1

(Continued)

Table 1 (Continued)

Gage Number	Longitude deg	Longitude min	Longitude sec	Latitude deg	Latitude min	Latitude sec	100-Year Elevation ft	500-Year Elevation ft
41	153	25	50	58	57	23	10.5	17.1
42	153	28	7	58	59	21	10.5	19.0
43	153	30	33	58	59	1	10.5	19.7
44	153	35	53	59	0	2	10.8	20.7
45	153	38	60	59	1	48	10.5	19.7
46	153	41	49	59	4	16	10.5	16.4
47	153	48	16	59	4	14	10.5	16.4
48	153	50	14	59	3	14	10.5	17.1
49	153	52	47	59	3	24	10.5	18.0
50	153	56	6	59	3	38	10.5	19.0
51	154	0	39	59	4	19	10.8	20.0
52	154	9	56	59	5	13	11.2	20.7
53	154	10	47	59	7	12	11.2	20.3
54	154	10	49	59	10	2	11.2	21.0
55	154	7	36	59	11	33	11.2	21.7
56	154	8	19	59	13	45	11.2	22.3
57	154	8	4	59	15	32	11.5	22.6
58	154	6	1	59	18	4	11.5	23.3
59	154	0	40	59	19	56	11.8	24.9
60	153	56	59	59	21	7	12.1	26.9
61	153	58	47	59	23	5	11.8	24.9
62	153	56	9	59	23	19	11.8	24.6
63	153	53	1	59	24	47	11.8	25.6
64	153	50	8	59	24	50	11.5	24.9
65	153	46	16	59	25	28	11.5	23.6
66	153	44	3	59	26	6	11.5	22.3
67	153	42	1	59	27	38	11.5	23.0
68	153	46	14	59	31	35	12.1	25.9
69	153	39	28	59	32	54	11.8	23.6
70	153	34	38	59	33	15	11.8	24.0
71	153	33	9	59	35	25	12.1	24.6
72	153	32	2	59	37	26	12.5	26.6
73	153	27	50	59	39	1	12.1	24.9
74	153	24	14	59	37	55	11.8	24.0
75	153	18	1	59	37	49	11.8	23.3
76	153	14	45	59	37	44	11.5	22.3
77	153	9	31	59	38	52	11.5	22.0
78	153	8	31	59	40	7	11.2	20.3
79	153	4	33	59	41	6	10.8	17.1
80	153	2	38	59	42	2	11.2	20.0

(Continued)

Table 1 (Continued)

Gage Number	Longitude deg	Longitude min	Longitude sec	Latitude deg	Latitude min	Latitude sec	100-Year Elevation ft	500-Year Elevation ft
81	153	0	33	59	45	5	11.8	22.3
82	152	59	22	59	48	13	12.5	25.9
83	153	1	4	59	49	37	14.8	32.5
84	153	8	20	59	48	9	15.4	34.5
85	153	13	51	59	48	58	15.7	36.1
86	153	13	41	59	52	5	16.1	36.7
87	153	8	26	59	51	28	15.7	34.8
88	153	4	6	59	51	53	14.8	32.8
89	153	1	44	59	52	36	13.8	29.5
90	152	59	31	59	52	42	13.1	26.6
91	152	56	37	59	52	22	12.1	24.3
92	152	52	17	59	52	13	11.5	21.7
93	152	49	25	59	52	9	11.2	18.7
94	152	43	42	59	54	3	11.5	13.8
95	152	41	7	59	56	36	11.5	14.1
96	152	37	33	59	59	29	11.8	14.1
97	152	34	22	60	2	52	11.8	14.4
98	152	33	24	60	5	12	11.8	14.1
99	152	34	17	60	9	18	11.5	13.8
100	152	36	55	60	10	23	11.5	13.5
101	152	33	31	60	13	1	11.8	14.4
102	152	30	32	60	15	11	11.8	15.4
103	152	24	41	60	17	21	11.8	14.4
104	152	22	30	60	20	35	11.5	12.5
105	152	18	37	60	21	38	11.5	12.5
106	152	14	11	60	23	36	11.5	12.5
107	152	17	30	60	24	48	11.5	12.5
108	152	18	57	60	29	4	11.5	12.5
109	152	16	39	60	31	37	11.5	12.5
110	152	13	6	60	33	23	11.5	12.5
111	152	10	15	60	34	24	11.5	12.5
112	152	6	5	60	35	30	12.8	14.8
113	152	4	55	60	36	58	12.8	15.1
114	152	4	2	60	38	11	11.5	14.1
115	152	1	48	60	42	12	12.8	15.1
116	151	58	33	60	43	29	12.8	15.1
117	151	54	42	60	45	31	12.8	15.1
118	151	49	48	60	44	53	12.8	15.1
119	151	45	47	60	43	21	12.8	15.1
120	151	42	57	60	42	37	12.5	14.4

(Continued)

Table 1 (Continued)

Gage Number	Longitude deg	Longitude min	Longitude sec	Latitude deg	Latitude min	Latitude sec	100-Year Elevation ft	500-Year Elevation ft
121	151	43	50	60	46	0	12.5	14.8
122	151	46	26	60	48	32	12.5	14.8
123	151	48	58	60	51	16	12.8	15.1
124	151	47	32	60	54	57	12.8	15.1
125	151	41	22	60	57	58	12.8	15.4
126	151	37	1	60	59	47	12.8	16.1
127	151	34	2	61	0	18	12.8	15.7
128	151	29	3	61	0	57	12.8	15.4
129	151	26	29	61	0	44	12.8	15.1
130	151	23	18	61	0	38	12.5	14.8
131	151	18	27	61	1	43	12.5	14.8
132	151	14	42	61	2	18	12.5	14.4
133	151	9	38	61	2	49	12.5	14.1
134	151	7	8	61	4	58	12.5	13.8
135	151	4	17	61	8	6	12.5	14.1
136	151	2	37	61	9	33	12.5	15.1
137	151	1	10	61	10	37	12.8	15.4
138	150	58	31	61	11	20	12.8	15.1
139	150	54	14	61	12	21	12.8	15.1
140	150	50	14	61	13	17	12.5	14.8
141	150	47	55	61	13	51	12.5	14.4
142	150	44	17	61	14	38	15.7	17.4
143	150	39	58	61	16	26	15.7	17.4
144	150	35	58	61	16	29	15.7	17.1
145	150	28	25	61	17	18	15.7	16.7
146	150	25	7	61	16	48	15.7	16.7
147	150	20	32	61	17	1	15.7	16.7
148	150	17	29	61	17	48	15.7	16.7
149	150	14	42	61	17	21	15.7	16.7
150	150	11	5	61	16	49	15.7	16.7
151	150	7	24	61	16	48	15.7	16.7
152	150	3	18	61	16	53	15.7	16.7
153	150	1	14	61	14	33	15.7	16.7
154	149	55	26	61	15	26	15.7	16.7
155	149	53	22	61	13	48	15.7	16.7
156	149	55	45	61	12	15	15.7	16.7
157	149	58	10	61	11	50	15.7	16.7
158	150	0	45	61	12	8	15.7	16.7
159	150	3	46	61	9	55	15.7	17.1
160	149	59	52	61	8	11	16.1	17.7

(Continued)

Table 1 (Continued)

Gage Number	Longitude deg	Longitude min	Longitude sec	Latitude deg	Latitude min	Latitude sec	100-Year Elevation ft	500-Year Elevation ft
161	149	55	42	61	6	40	16.1	18.0
162	149	51	38	61	5	50	16.1	18.0
163	149	49	17	61	4	3	16.1	18.4
164	149	44	29	61	1	8	16.1	18.4
165	149	41	14	61	0	15	16.1	18.0
166	149	38	18	60	59	53	16.1	17.7
167	149	34	51	60	58	54	16.1	18.0
168	149	31	40	60	58	56	16.1	19.0
169	149	29	33	60	58	56	16.1	20.0
170	149	26	20	60	57	50	16.4	21.3
171	149	22	43	60	56	52	16.4	22.6
172	149	19	11	60	55	56	16.7	23.6
173	149	12	34	60	56	29	16.7	24.6
174	149	9	31	60	55	53	16.7	25.3
175	149	3	46	60	53	48	13.8	23.0
176	149	3	22	60	51	24	13.8	22.6
177	149	7	48	60	53	14	16.7	24.9
178	149	10	32	60	53	14	16.7	24.3
179	149	15	38	60	53	39	16.7	23.6
180	149	20	53	60	53	37	16.4	22.3
181	149	22	60	60	53	49	16.4	21.3
182	149	25	11	60	54	14	16.1	20.0
183	149	28	52	60	55	4	16.1	19.0
184	149	33	42	60	56	1	16.1	18.4
185	149	37	52	60	55	24	16.1	18.0
186	149	40	38	60	56	43	16.1	18.0
187	149	46	7	60	57	53	16.1	18.0
188	149	49	56	60	58	2	16.1	18.0
189	149	53	33	60	56	27	16.1	18.4
190	149	55	25	60	54	43	16.1	18.0
191	150	0	41	60	51	44	16.1	18.0
192	150	6	4	60	53	2	16.1	18.0
193	150	11	38	60	53	57	16.1	18.0
194	150	15	21	60	56	35	16.1	18.0
195	150	18	11	60	58	51	15.7	17.1
196	150	19	41	61	0	42	15.7	16.7
197	150	23	41	61	2	9	15.7	16.7
198	150	27	6	61	0	50	15.7	17.1
199	150	30	47	60	59	55	15.7	17.4
200	150	34	30	60	58	55	15.7	17.4

(Continued)

Table 1 (Continued)

Gage Number	Longitude deg	Longitude min	Longitude sec	Latitude deg	Latitude min	Latitude sec	100-Year Elevation ft	500-Year Elevation ft
201	150	40	57	60	57	15	12.5	14.4
202	150	42	34	60	55	57	12.5	14.8
203	150	45	45	60	54	40	12.5	14.8
204	150	48	48	60	53	12	12.5	14.8
205	150	53	3	60	51	27	12.5	14.8
206	150	56	44	60	50	1	12.5	15.1
207	150	59	20	60	48	53	12.5	15.1
208	151	1	22	60	47	58	12.5	14.8
209	151	4	33	60	47	2	12.5	14.8
210	151	11	8	60	46	41	12.5	14.8
211	151	15	15	60	46	19	12.5	14.4
212	151	17	27	60	44	32	12.5	14.4
213	151	23	3	60	43	38	12.5	14.8
214	151	24	28	60	42	47	12.5	14.8
215	151	22	30	60	40	4	12.8	15.1
216	151	20	33	60	37	0	12.8	15.1
217	151	19	49	60	34	59	12.8	15.7
218	151	16	35	60	33	13	12.8	15.7
219	151	16	37	60	30	35	12.8	15.7
220	151	16	44	60	27	27	12.8	15.4
221	151	17	16	60	25	0	12.8	15.1
222	151	18	17	60	23	15	12.8	14.8
223	151	22	35	60	21	15	12.8	15.1
224	151	22	40	60	18	44	12.8	15.1
225	151	23	30	60	14	45	12.8	15.1
226	151	25	45	60	11	51	12.8	14.8
227	151	28	55	60	9	40	12.8	14.4
228	151	31	31	60	7	52	12.8	14.1
229	151	35	2	60	6	3	12.8	14.1
230	151	37	47	60	4	15	12.8	14.1
231	151	40	4	60	2	29	12.8	13.8
232	151	42	36	60	0	33	12.5	13.8
233	151	43	26	59	58	13	12.8	13.8
234	151	44	36	59	55	34	12.8	14.1
235	151	45	53	59	53	53	12.8	14.1
236	151	47	56	59	52	15	12.8	14.4
237	151	49	30	59	48	51	12.8	15.4
238	151	50	50	59	47	25	12.8	15.7
239	151	51	47	59	45	25	12.8	15.7
240	151	51	11	59	44	28	12.8	15.7

(Continued)

Table 1 (Continued)

Gage Number	Longitude deg	Longitude min	Longitude sec	Latitude deg	Latitude min	Latitude sec	100-Year Elevation ft	500-Year Elevation ft
241	151	50	21	59	43	34	13.1	16.4
242	151	47	26	59	41	47	13.1	19.0
243	151	42	23	59	39	54	13.5	21.0
244	151	38	24	59	38	32	13.5	22.0
245	151	33	41	59	37	59	13.5	21.7
246	151	31	0	59	37	36	13.5	21.3
247	151	25	11	59	35	46	13.1	19.0
248	151	23	24	59	40	17	13.5	20.3
249	151	17	18	59	41	41	13.5	22.0
250	151	14	37	59	42	39	13.8	23.3
251	151	10	13	59	44	38	15.4	30.8
252	151	7	22	59	45	54	16.1	35.4
253	151	4	34	59	46	53	16.7	37.7
254	151	1	2	59	44	20	16.7	37.4
255	151	4	2	59	42	54	16.1	35.1
256	151	6	46	59	40	49	14.4	26.6
257	151	8	27	59	39	23	14.1	24.3
258	151	11	22	59	38	17	13.5	22.3
259	151	16	4	59	35	28	13.5	20.7
260	151	17	55	59	34	21	13.1	17.4
261	151	20	36	59	33	45	13.1	18.0
262	151	22	21	59	31	54	13.1	17.7
263	151	25	55	59	32	12	11.8	17.4
264	151	27	48	59	29	18	12.1	19.7
265	151	30	9	59	28	8	12.5	21.0
266	151	35	53	59	28	9	12.5	20.7
267	151	38	50	59	28	40	12.1	20.0
268	151	42	3	59	27	48	12.1	19.7
269	151	47	3	59	26	9	12.1	19.4
270	151	52	55	59	25	16	12.1	19.0
271	151	53	3	59	22	37	12.1	19.0
272	151	53	11	59	21	14	12.1	19.4
273	151	55	47	59	20	41	12.1	18.0
274	151	59	11	59	18	9	12.1	18.4
275	151	58	34	59	16	35	12.1	19.4
276	151	57	23	59	14	40	12.1	20.0
277	151	54	38	59	13	25	12.8	23.3
278	151	51	43	59	12	28	12.8	24.0
279	151	47	38	59	12	19	13.1	24.3
280	151	44	59	59	9	41	13.1	24.9

(Continued)

Table 1 (Continued)

Gage Number	Longitude deg	Longitude min	Longitude sec	Latitude deg	Latitude min	Latitude sec	100-Year Elevation ft	500-Year Elevation ft
281	151	42	3	59	9	32	13.5	25.9
282	151	38	28	59	9	39	13.8	28.2
283	151	35	25	59	9	34	15.1	35.4
284	151	33	6	59	12	2	14.4	32.8
285	151	27	23	59	12	15	14.1	28.9
286	151	21	59	59	14	12	14.4	30.8
287	151	17	54	59	12	28	14.1	29.5
288	151	13	39	59	12	13	13.8	28.9
289	151	9	29	59	12	0	13.8	29.9
290	151	5	52	59	13	17	15.1	33.5
291	151	7	1	59	15	8	16.7	39.0
292	151	16	24	59	17	33	17.7	41.7
293	151	13	17	59	17	46	17.7	43.0
294	151	9	8	59	16	50	17.1	39.7
295	151	4	54	59	16	3	16.4	37.1
296	151	2	14	59	17	27	16.1	36.1
297	151	0	49	59	14	44	15.7	35.1
298	151	0	24	59	13	4	15.1	33.1
299	150	58	1	59	11	58	13.8	30.8
300	150	55	60	59	13	49	13.8	31.2
301	150	53	39	59	15	5	13.5	29.2
302	150	51	48	59	19	21	15.7	38.1
303	150	48	29	59	21	14	16.7	41.3
304	150	45	47	59	22	35	16.7	41.0
305	150	40	56	59	25	42	16.1	39.0
306	150	36	45	59	25	31	16.4	40.4
307	150	34	57	59	26	33	18.4	46.3
308	150	34	53	59	28	7	19.4	50.5
309	150	36	10	59	32	18	20.3	54.5
310	150	33	40	59	34	55	21.3	57.4
311	150	30	10	59	35	18	21.0	56.8
312	150	33	8	59	31	18	20.3	54.5
313	150	31	18	59	29	50	19.4	50.5
314	150	31	8	59	27	59	18.0	46.3
315	150	28	30	59	27	36	15.4	36.4
316	150	27	41	59	28	35	15.7	37.7
317	150	25	56	59	30	44	15.4	36.1
318	150	24	56	59	32	41	15.7	37.7
319	150	22	59	59	34	8	15.7	37.7
320	150	22	17	59	29	23	15.7	37.7

(Continued)

Table 1 (Continued)

Gage Number	Longitude deg	Longitude min	Longitude sec	Latitude deg	Latitude min	Latitude sec	100-Year Elevation ft	500-Year Elevation ft
321	150	17	46	59	25	1	13.1	28.5
322	150	15	5	59	29	8	13.5	30.5
323	150	12	17	59	31	17	14.1	32.8
324	150	10	17	59	32	21	17.4	44.6
325	150	7	30	59	33	55	14.4	34.1
326	150	5	8	59	34	47	14.8	35.1
327	150	6	0	59	36	27	15.4	38.1
328	150	0	13	59	38	2	14.8	35.1
329	149	56	53	59	39	28	14.1	33.1
330	149	55	16	59	41	13	14.1	31.8
331	149	52	51	59	44	30	15.1	36.1
332	149	49	18	59	42	7	15.1	35.8
333	149	47	40	59	37	56	14.4	32.5
334	149	44	9	59	39	37	13.5	29.5
335	149	43	12	59	41	41	14.1	32.5
336	149	43	32	59	43	10	14.1	32.8
337	149	45	10	59	45	28	14.4	33.8
338	149	45	28	59	47	27	15.7	37.4
339	149	44	54	59	49	18	15.4	36.7
340	149	44	21	59	51	16	16.7	41.3
341	149	44	1	59	56	9	17.4	43.6
342	149	39	44	59	55	24	17.1	43.0
343	149	39	44	59	52	16	16.4	41.0
344	149	39	51	59	49	21	15.1	35.8
345	149	38	56	59	46	18	15.1	35.1
346	149	36	34	59	43	39	14.4	33.1
347	149	31	24	59	42	30	13.8	31.5
348	149	32	35	59	45	14	13.5	29.9
349	149	32	2	59	46	29	14.4	33.5
350	149	35	36	59	48	20	14.8	35.1
351	149	34	5	59	51	7	14.4	32.8
352	149	31	14	59	55	33	16.4	39.7
353	149	27	13	59	55	30	16.4	39.4
354	149	25	29	59	58	27	17.1	41.7
355	149	24	8	60	0	36	17.7	43.6
356	149	25	58	60	4	4	18.7	46.6
357	149	26	5	60	7	1	20.3	52.5
358	149	21	32	60	6	43	20.0	51.8
359	149	20	33	60	4	54	18.7	45.9
360	149	19	43	60	0	44	19.4	50.2

(Continued)

Table 1 (Continued)

Gage Number	Longitude deg	Longitude min	Longitude sec	Latitude deg	Latitude min	Latitude sec	100-Year Elevation ft	500-Year Elevation ft
361	149	18	47	59	58	18	19.0	48.6
362	149	20	45	59	56	16	16.4	39.7
363	149	17	10	59	54	8	15.1	35.4
364	149	16	51	59	52	7	14.1	32.2
365	149	14	41	59	54	42	13.5	29.5
366	149	12	45	59	56	33	13.8	30.2
367	149	12	26	59	58	27	14.1	31.5
368	149	11	6	60	0	7	14.8	33.8
369	149	5	33	60	2	39	15.4	36.1
370	149	3	1	60	3	4	15.7	36.7
371	149	2	42	60	1	42	15.7	36.7
372	149	5	30	59	59	38	15.1	34.1
373	149	6	59	59	57	56	14.1	30.5
374	149	1	12	59	57	3	13.1	26.6
375	148	57	50	59	58	5	13.1	26.2
376	148	53	6	59	56	35	13.1	25.9
377	148	49	52	59	55	34	12.8	24.9
378	148	45	7	59	57	26	12.5	23.0
379	148	42	31	59	56	23	12.5	22.6
380	148	38	6	59	55	3	12.5	23.0
381	148	36	0	59	55	39	12.8	25.3
382	148	33	8	59	57	28	13.5	27.9
383	148	26	32	59	56	41	10.8	26.2
384	148	23	58	59	58	42	10.8	25.9
385	148	24	14	60	1	49	12.1	28.5
386	148	22	51	60	3	41	12.8	30.5
387	148	22	13	60	5	11	13.8	34.1
388	148	21	45	60	7	13	14.4	36.7
389	148	17	17	60	8	43	14.4	36.4
390	148	17	48	60	6	58	13.8	33.8
391	148	17	19	60	5	26	12.8	30.8
392	148	18	50	60	1	50	12.1	28.9
393	148	16	7	60	0	40	11.2	26.9
394	148	0	31	59	56	35	11.2	27.9
395	147	52	52	59	58	60	13.5	35.4
396	147	49	5	60	3	34	10.5	24.3
397	147	52	34	60	3	57	10.2	23.6
398	147	57	49	60	0	40	10.5	24.9
399	148	2	24	59	57	33	10.5	24.3
400	148	8	55	59	59	32	10.2	22.6

(Continued)

Table 1 (Continued)

Gage Number	Longitude deg	Longitude min	Longitude sec	Latitude deg	Latitude min	Latitude sec	100-Year Elevation ft	500-Year Elevation ft
401	147	54	3	60	7	16	10.2	23.3
402	148	12	23	60	15	18	9.8	19.4
403	148	22	19	60	11	50	10.5	22.0
404	148	22	42	60	16	35	10.5	21.7
405	148	14	53	60	16	33	9.8	19.7
406	148	12	28	60	19	19	9.8	19.4
407	148	10	10	60	19	57	10.2	20.7
408	148	6	25	60	22	27	10.2	20.7
409	148	2	58	60	23	12	10.2	20.7
410	147	57	57	60	24	53	10.2	20.7
411	147	58	55	60	28	11	10.2	21.7
412	147	58	31	60	30	49	10.5	22.6
413	148	2	48	60	33	54	10.8	24.3
414	148	5	47	60	35	36	10.8	23.6
415	148	9	11	60	34	5	10.5	22.3
416	148	12	35	60	31	54	10.5	22.6
417	148	14	48	60	30	8	10.8	23.3
418	148	19	31	60	29	34	10.8	23.3
419	148	22	25	60	30	28	10.8	23.3
420	148	25	54	60	31	37	11.2	25.3
421	148	28	12	60	31	50	11.5	25.9
422	148	34	19	60	29	44	11.8	26.6
423	148	36	37	60	28	17	12.5	29.2
425	148	35	48	60	31	29	12.1	27.2
426	148	33	35	60	32	21	11.5	25.6
427	148	30	41	60	33	36	11.5	26.2
428	148	26	52	60	33	48	11.5	25.6
429	148	24	3	60	32	22	10.8	23.6
430	148	19	44	60	31	24	10.8	23.3
431	148	16	4	60	34	25	10.8	23.0
432	148	11	12	60	36	10	10.8	24.3
433	148	13	46	60	45	25	12.8	30.5
434	148	17	35	60	43	38	13.1	31.5
435	148	21	21	60	40	7	13.1	31.5
436	148	24	14	60	39	30	13.1	30.8
437	148	23	25	60	42	56	12.8	30.8
438	148	21	51	60	45	24	12.8	30.8
439	148	25	2	60	45	59	12.8	30.2
440	148	31	14	60	45	26	13.5	31.8

(Continued)

Table 1 (Continued)

Gage Number	Longitude deg	Longitude min	Longitude sec	Latitude deg	Latitude min	Latitude sec	100-Year Elevation ft	500-Year Elevation ft
441	148	37	5	60	44	37	13.5	32.5
442	148	32	19	60	48	46	13.5	32.5
443	148	20	44	60	47	43	12.8	30.2
444	148	17	22	60	51	21	13.5	32.5
445	148	16	0	60	54	3	14.1	35.1
446	148	11	1	60	57	26	15.1	38.4
447	148	12	22	61	3	5	15.7	40.4
448	148	21	34	61	1	43	16.1	41.7
449	148	16	5	61	4	7	15.7	41.0
450	148	7	17	61	3	22	15.4	39.4
451	148	5	8	60	59	46	15.7	40.7
452	148	0	5	61	2	47	17.4	45.6
453	147	58	25	61	5	60	18.4	48.9
454	147	54	33	61	8	22	19.0	50.9
455	147	50	4	61	11	6	19.7	53.2
456	147	45	59	61	10	28	20.0	53.5
457	147	47	60	61	9	1	20.0	53.2
458	147	50	5	61	7	60	18.4	48.9
459	147	52	16	61	6	18	17.4	45.6
460	147	55	54	61	4	11	16.4	43.0
461	147	56	56	61	1	18	16.1	41.3
462	147	59	7	60	59	4	15.7	40.0
463	148	1	48	60	56	51	15.1	37.7
464	148	5	37	60	54	23	14.8	37.4
465	148	7	4	60	51	58	13.8	33.1
466	148	8	15	60	49	27	13.1	32.2
467	148	7	35	60	46	56	11.8	27.9
468	148	1	43	60	46	31	11.5	26.6
469	147	55	21	60	48	7	11.5	25.9
470	147	49	8	60	48	19	10.8	24.3
471	147	37	22	60	50	15	10.5	23.0
472	147	35	15	60	52	13	10.5	23.0
473	147	35	57	60	53	50	10.5	23.6
474	147	35	59	60	55	29	10.8	24.3
475	147	37	7	60	57	45	11.2	25.6
476	147	35	57	60	59	5	11.8	27.6
477	147	35	6	61	0	41	11.8	27.9
478	147	35	14	61	2	11	12.1	28.5
479	147	33	27	61	4	22	13.1	32.5
480	147	30	29	61	4	11	13.1	32.2

(Continued)

Table 1 (Continued)

Gage Number	Longitude deg	Longitude min	Longitude sec	Latitude deg	Latitude min	Latitude sec	100-Year Elevation ft	500-Year Elevation ft
481	147	31	37	61	2	4	12.1	28.9
482	147	31	27	60	59	46	12.1	28.2
483	147	32	17	60	57	45	11.8	27.9
484	147	32	1	60	55	35	11.2	25.3
485	147	32	10	60	53	32	10.8	24.6
486	147	27	1	60	53	33	10.5	23.3
487	147	22	43	60	51	53	10.5	22.3
488	147	18	26	60	53	56	11.5	26.9
489	147	15	18	60	56	26	12.5	29.5
490	147	13	10	60	57	50	12.1	28.9
491	147	11	5	60	55	35	11.8	26.9
492	147	2	53	60	56	18	11.5	25.9
493	146	58	17	60	55	20	10.8	23.0
494	146	55	15	60	56	7	10.5	23.0
495	146	52	57	60	57	15	10.8	23.3
496	146	50	44	60	59	19	10.8	23.0
497	146	48	22	61	0	59	10.5	22.3
498	146	43	28	61	2	30	12.5	28.9
499	146	39	3	61	5	30	13.1	30.8
500	146	34	27	61	6	34	13.5	32.2
501	146	30	56	61	6	54	14.1	35.1
502	146	28	2	61	7	17	14.8	37.7
503	146	24	10	61	7	8	14.8	37.7
504	146	20	28	61	6	56	14.8	38.1
505	146	15	51	61	6	21	15.4	40.4
506	146	16	46	61	4	41	15.4	40.0
507	146	20	28	61	4	39	15.1	37.4
508	146	24	31	61	4	39	14.4	35.8
509	146	28	26	61	4	15	14.1	34.8
510	146	31	33	61	4	26	13.5	32.2
511	146	34	37	61	4	24	13.1	30.2
512	146	39	47	61	3	12	11.2	24.6
513	146	41	9	61	0	0	10.8	23.6
514	146	45	19	60	57	1	10.5	22.6
515	146	44	5	60	54	5	10.5	22.3
516	146	47	40	60	51	17	10.5	22.6
517	146	48	44	60	49	26	10.5	22.3
518	146	47	33	60	47	54	10.5	23.0
519	146	43	41	60	48	13	10.5	22.6
520	146	38	10	60	48	40	10.5	22.3

(Continued)

Table 1 (Continued)

Gage Number	Longitude deg	Longitude min	Longitude sec	Latitude deg	Latitude min	Latitude sec	100-Year Elevation ft	500-Year Elevation ft
521	146	33	24	60	48	9	10.5	22.0
522	146	27	13	60	48	21	10.8	23.3
523	146	23	19	60	48	28	11.2	24.6
524	146	19	45	60	49	0	11.5	25.6
525	146	17	21	60	49	51	12.1	27.6
526	146	13	16	60	51	27	12.1	27.6
527	146	14	32	60	50	5	11.5	26.2
528	146	16	38	60	48	11	11.5	26.2
529	146	20	29	60	46	53	11.5	25.9
530	146	26	14	60	46	19	11.2	24.9
531	146	31	18	60	46	11	10.8	23.6
532	146	36	13	60	45	12	10.5	22.0
533	146	41	47	60	44	13	10.5	22.6
534	146	39	14	60	40	56	10.5	22.6
535	146	34	51	60	40	58	10.8	24.6
536	146	29	45	60	40	29	10.8	24.0
537	146	25	54	60	40	42	11.2	24.6
538	146	22	57	60	41	38	11.2	24.6
539	146	21	10	60	43	12	11.5	25.6
540	146	17	25	60	42	30	10.8	23.6
541	146	9	56	60	43	7	11.2	24.9
542	146	6	14	60	44	36	11.8	27.2
543	146	3	11	60	45	8	11.8	27.6
544	146	4	55	60	43	21	11.5	25.9
545	146	7	15	60	42	24	11.5	25.6
546	146	10	13	60	41	16	10.8	24.0
547	146	12	35	60	40	3	10.5	23.0
548	146	16	1	60	38	31	11.2	25.3
549	146	12	51	60	37	18	10.8	24.3
550	146	7	58	60	37	60	10.8	23.6
551	146	1	48	60	39	35	11.5	25.9
552	145	59	52	60	38	12	11.5	25.9
553	145	57	12	60	37	0	11.8	26.9
554	145	52	56	60	38	18	12.1	27.2
555	145	44	32	60	37	47	13.1	28.9
556	145	37	50	60	38	22	13.8	31.8
557	145	40	36	60	36	32	13.8	32.2
558	145	42	5	60	35	5	13.1	29.5
559	145	44	28	60	33	21	12.8	27.9
560	145	47	23	60	31	21	12.8	28.9

(Continued)

Table 1 (Continued)

Gage Number	Longitude deg	Longitude min	Longitude sec	Latitude deg	Latitude min	Latitude sec	100-Year Elevation ft	500-Year Elevation ft
561	145	51	30	60	29	56	12.1	27.2
562	145	57	24	60	27	46	11.8	25.9
563	145	53	45	60	26	38	11.8	26.2
564	145	42	20	60	28	6	13.1	29.2
565	145	36	31	60	22	39	13.1	30.2
566	145	53	25	60	34	59	11.5	25.6
567	146	0	13	60	33	39	11.2	24.0
568	146	9	9	60	31	16	10.8	24.0
569	146	17	2	60	30	42	11.2	24.0
570	146	18	12	60	26	50	10.8	22.6
571	146	9	9	60	27	35	11.8	25.9
572	146	3	9	60	29	7	11.8	25.3
573	145	55	54	60	31	8	13.1	29.2
574	145	48	41	60	33	13	12.5	26.9
575	146	5	12	60	22	47	11.5	25.6
576	146	14	38	60	19	53	12.1	28.2
577	146	19	23	60	20	9	12.5	29.2
578	146	25	22	60	18	37	12.8	30.2
579	146	30	23	60	16	40	11.5	25.3
580	146	36	22	60	13	54	11.2	24.6
581	146	41	53	60	16	23	10.8	23.0
582	146	43	19	60	20	18	10.5	22.3
583	146	43	32	60	23	3	10.5	22.0
584	146	39	58	60	26	3	10.5	21.7
585	146	36	53	60	28	35	10.8	22.6
586	146	25	28	60	27	59	10.8	23.0
587	146	21	27	60	26	23	10.8	24.0
588	146	20	26	60	24	6	11.5	24.9
589	146	13	0	60	25	4	11.5	24.6
590	147	8	12	60	22	12	10.5	22.0
591	147	0	50	60	20	19	10.5	21.7
592	146	55	0	60	16	60	10.8	23.0
593	147	4	43	60	11	43	11.2	24.0
594	147	10	2	60	9	38	11.5	25.6
595	147	13	22	60	7	44	12.1	27.2
596	147	16	17	60	5	44	12.5	29.2
597	147	19	53	60	3	27	12.8	30.5
598	147	22	44	60	0	37	12.5	29.2
599	147	21	10	59	57	50	12.1	27.6
600	147	27	53	59	56	58	13.5	32.5

(Continued)

Table 1 (Continued)

Gage Number	Longitude deg	Longitude min	Longitude sec	Latitude deg	Latitude min	Latitude sec	100-Year Elevation ft	500-Year Elevation ft
601	147	26	37	59	54	2	13.1	30.8
602	147	29	33	59	51	1	12.5	28.5
603	147	33	31	59	50	57	11.8	28.9
604	147	38	17	59	50	16	11.8	29.2
605	147	40	39	59	47	56	12.1	29.9
606	147	44	26	59	48	6	13.5	33.8
607	147	48	50	59	46	40	14.4	38.1
608	147	53	11	59	45	60	14.4	38.1
609	147	53	54	59	48	55	13.8	34.8
610	147	53	7	59	51	40	13.8	36.1
611	147	48	5	59	53	27	14.8	38.4
612	147	45	19	59	56	36	13.8	35.1
613	147	42	18	59	58	53	12.5	30.8
614	147	38	9	60	0	26	11.5	27.2
615	147	34	20	60	1	41	11.8	27.6
616	147	30	53	60	3	38	12.5	29.9
617	147	26	39	60	5	12	12.8	31.2
618	147	23	42	60	7	24	12.5	28.9
619	147	22	15	60	9	27	11.8	26.6
620	147	18	49	60	12	55	12.5	28.2
621	147	14	10	60	13	60	12.5	27.6
622	147	11	31	60	16	17	11.8	26.6
623	147	10	12	60	18	35	11.2	24.0
624	147	12	28	60	20	22	10.8	23.3
625	147	36	5	60	29	58	10.2	21.0
626	147	37	46	60	27	13	10.5	23.0
627	147	36	38	60	25	48	10.5	23.0
628	147	37	7	60	22	49	10.5	22.3
629	147	38	15	60	20	13	10.2	22.0
630	147	40	5	60	18	23	10.8	23.6
631	147	43	9	60	15	58	10.5	23.0
632	147	42	15	60	13	33	10.5	22.3
633	147	43	48	60	11	41	10.5	23.3
634	147	45	11	60	9	49	10.2	22.6
635	147	47	21	60	9	39	10.2	23.0
636	147	50	3	60	11	8	9.5	18.4
637	147	53	3	60	13	20	9.5	18.4
638	147	55	52	60	16	2	9.5	19.0
639	147	52	32	60	19	35	9.8	19.4
640	147	51	1	60	23	6	9.8	19.7

(Continued)

Table 1 (Continued)

Gage Number	Longitude deg	Longitude min	Longitude sec	Latitude deg	Latitude min	Latitude sec	100-Year Elevation ft	500-Year Elevation ft
641	147	49	34	60	25	27	9.8	20.7
642	147	47	25	60	27	40	10.2	21.3
643	147	43	8	60	30	5	10.8	24.0
644	147	38	55	60	32	6	10.5	23.3
645	147	33	2	60	33	12	10.2	21.0
646	147	18	42	60	39	10	10.2	21.7
647	147	21	29	60	37	15	10.2	21.3
648	147	25	60	60	37	13	10.2	21.0
649	147	29	51	60	38	36	10.5	22.3
650	147	28	45	60	43	3	10.2	22.0
651	147	23	15	60	44	3	10.2	21.7
652	147	21	42	60	41	56	10.2	21.3
653	147	52	12	60	39	47	10.8	24.3
654	147	56	54	60	39	40	11.2	25.3
655	147	59	55	60	40	46	11.5	26.6
656	148	0	47	60	43	4	11.2	25.6
657	147	54	37	60	43	41	10.8	23.6
658	147	16	11	60	51	46	10.8	23.3
659	147	8	41	60	54	13	11.8	26.9
660	147	4	18	60	53	5	10.5	23.0
661	147	8	3	60	50	50	10.2	21.7
662	147	59	31	60	20	39	9.5	18.7
663	148	5	4	60	16	26	9.8	19.0
664	148	8	18	60	17	14	9.8	19.4
665	148	5	29	60	21	10	9.8	19.4
666	145	30	54	60	19	51	13.8	32.5
667	145	24	13	60	17	43	13.8	32.5
668	145	21	9	60	16	33	13.8	33.1
669	145	15	39	60	14	27	13.8	31.8
670	145	8	46	60	13	6	12.5	27.2
671	144	57	1	60	12	25	15.1	41.0
672	144	50	45	60	12	17	14.4	37.7
673	144	43	49	60	11	26	14.8	40.0
674	144	41	10	60	8	59	14.1	37.1
675	144	38	42	60	7	11	13.5	33.8
676	144	34	48	60	6	7	12.1	28.9
677	144	27	22	60	4	49	12.8	30.5
678	144	20	23	60	6	41	13.5	33.8
679	144	16	35	60	4	38	13.8	34.1
680	144	12	50	60	3	0	14.8	38.7

(Continued)

Table 1 (Continued)

Gage Number	Longitude deg	Longitude min	Longitude sec	Latitude deg	Latitude min	Latitude sec	100-Year Elevation ft	500-Year Elevation ft
681	144	9	3	60	1	29	14.8	39.0
682	144	5	34	59	59	29	13.8	35.1
683	144	8	47	59	57	16	12.5	29.5
684	144	15	34	59	55	44	13.1	32.5
685	144	22	28	59	54	5	11.8	27.2
686	144	29	44	59	49	56	11.8	27.2
687	144	36	41	59	45	9	9.8	20.7
688	144	36	16	59	44	17	9.5	19.0
689	144	33	0	59	46	21	9.8	19.4
690	144	29	35	59	48	1	9.5	19.0
691	144	25	5	59	50	25	9.8	20.0
692	144	19	35	59	53	2	9.5	18.7
693	144	4	25	59	56	37	10.5	21.7
694	144	0	57	59	55	43	10.2	21.3
695	143	57	26	59	54	43	9.8	21.3
696	143	53	42	59	55	2	9.8	21.7
697	143	49	34	59	55	46	9.8	21.7
698	143	46	3	59	56	15	9.8	21.7
699	143	42	5	59	56	25	9.8	21.3
700	143	38	40	59	56	42	9.5	20.7
701	143	34	14	59	56	51	9.2	19.0
702	143	30	25	59	57	6	9.2	18.0
703	143	26	31	59	57	4	7.5	16.7
704	143	23	10	59	57	5	7.5	16.1
705	143	18	50	59	57	11	7.2	15.4
706	143	15	21	59	57	9	7.2	14.8
707	143	11	6	59	57	18	7.2	14.1
708	143	7	20	59	57	31	7.2	13.8
709	143	3	41	59	58	21	7.2	13.1
710	143	0	15	59	59	1	6.9	12.8
711	142	55	43	59	59	33	7.5	13.8
712	142	51	55	59	59	38	7.2	13.1
713	142	48	22	59	59	42	7.2	13.1
714	142	44	33	59	59	57	7.2	12.8
715	142	40	30	59	59	59	7.2	12.8
716	142	37	22	59	59	45	7.2	13.1
717	142	33	19	59	59	24	7.2	13.8
718	142	22	59	60	4	25	7.2	13.1
719	142	19	12	60	3	59	7.2	12.1
720	142	15	4	60	3	39	6.9	11.2

(Continued)

Table 1 (Continued)

Gage Number	Longitude deg	Longitude min	Longitude sec	Latitude deg	Latitude min	Latitude sec	100-Year Elevation ft	500-Year Elevation ft
721	142	12	14	60	3	14	7.2	12.8
722	142	7	19	60	2	24	7.2	13.5
723	142	3	32	60	2	1	7.2	13.8
724	141	59	33	60	1	45	7.2	13.8
725	141	55	54	60	1	20	7.2	14.1
726	141	52	35	60	0	51	7.2	13.5
727	141	48	12	59	59	29	6.9	12.1
728	141	43	52	59	57	56	6.9	10.5
729	141	39	45	59	58	2	6.9	10.8
730	141	36	21	59	58	17	6.9	10.5
731	141	32	37	59	59	12	6.9	10.8
732	141	28	38	60	0	13	7.2	11.8
733	141	23	60	60	1	13	8.9	18.7
734	141	24	4	60	3	24	9.5	21.7
735	141	27	11	60	5	34	9.8	23.0
736	141	24	35	60	8	36	10.2	24.0
737	141	22	1	60	6	11	9.8	23.6
738	141	14	3	60	7	1	10.2	23.3
739	141	19	38	60	4	2	9.5	22.0
740	141	16	11	60	0	45	9.2	20.3
741	141	16	21	59	58	59	8.9	18.7
742	141	19	50	59	56	38	8.2	16.7
743	141	26	38	59	55	54	7.2	12.1
744	141	24	31	59	52	45	6.9	11.2
745	141	20	37	59	51	48	6.9	10.5
746	141	16	56	59	50	58	6.9	10.8
747	141	12	34	59	50	1	6.9	11.8
748	141	5	48	59	48	13	6.9	11.8
749	140	57	26	59	45	46	6.9	11.5
750	140	49	31	59	44	33	6.9	11.2
751	140	45	22	59	44	9	6.9	10.8
752	140	41	55	59	43	20	6.9	11.2
753	140	37	47	59	42	49	6.9	11.2
754	140	33	45	59	42	55	6.9	10.2
755	140	30	9	59	42	60	6.9	9.8
756	140	26	20	59	42	50	6.9	10.5
757	140	22	17	59	42	43	6.9	10.2
758	140	18	54	59	41	1	6.9	10.8
759	140	13	13	59	42	9	6.9	11.8
760	140	9	20	59	43	53	7.5	14.4

(Continued)

Table 1 (Continued)

Gage Number	Longitude deg	Longitude min	Longitude sec	Latitude deg	Latitude min	Latitude sec	100-Year Elevation ft	500-Year Elevation ft
761	140	3	21	59	45	7	7.5	14.8
762	139	58	2	59	46	34	7.5	15.1
763	139	53	20	59	47	28	7.9	15.7
764	139	49	9	59	48	18	7.9	15.4
765	139	46	48	59	49	29	7.5	15.4
766	139	45	53	59	52	15	7.9	17.4
767	139	37	26	59	50	25	7.9	18.0
768	139	35	42	59	48	4	7.9	17.4
769	139	33	59	59	45	22	7.9	16.1
770	139	35	24	59	42	5	7.5	15.7
771	139	31	46	59	39	46	7.5	15.4
772	139	35	32	59	37	2	7.9	15.7
773	139	43	30	59	37	42	7.5	14.8
774	139	48	16	59	34	35	6.9	12.1
775	139	51	27	59	31	29	6.9	11.5
776	139	46	26	59	29	57	6.9	12.8
777	139	41	32	59	28	13	6.9	12.1
778	139	36	54	59	26	40	6.9	12.1
779	139	31	35	59	24	29	7.2	14.1
780	139	26	56	59	22	44	7.2	15.4
781	139	22	17	59	21	19	7.2	15.7
782	139	15	59	59	19	34	6.9	13.8
783	139	11	7	59	18	27	8.2	19.0
784	139	7	20	59	17	34	7.9	17.1
785	139	3	45	59	16	36	7.5	14.8
786	138	58	58	59	15	22	7.9	15.7
787	138	55	11	59	14	22	7.9	17.1
788	138	51	35	59	13	13	7.5	15.4
789	138	47	31	59	11	36	7.5	15.7
790	138	44	9	59	10	4	7.5	15.7
791	138	41	1	59	8	37	7.5	15.7
792	138	31	33	59	10	24	7.5	15.4
793	138	34	26	59	6	31	7.2	15.1
794	138	30	9	59	5	34	7.2	13.1
795	138	25	60	59	4	35	7.2	13.5
796	138	21	46	59	3	43	7.2	14.1
797	138	16	57	59	2	43	7.5	15.4
798	138	13	12	59	1	33	7.2	13.8
799	138	10	50	59	0	13	7.5	14.4
800	138	7	48	58	58	38	7.5	14.8

(Continued)

Table 1 (Continued)

Gage Number	Longitude deg	Longitude min	Longitude sec	Latitude deg	Latitude min	Latitude sec	100-Year Elevation ft	500-Year Elevation ft
801	138	1	29	58	55	34	7.9	16.7
802	137	57	28	58	53	7	7.9	17.4
803	137	55	29	58	50	23	7.5	16.1
804	137	56	43	58	47	57	7.2	14.1
805	137	52	49	58	45	16	7.2	13.1
806	137	46	24	58	42	24	7.2	15.1
807	137	41	39	58	39	46	7.2	14.1
808	137	40	29	58	37	18	6.9	11.8
809	137	36	2	58	35	35	6.9	10.8
810	137	30	23	58	33	23	6.9	10.5
811	137	24	33	58	30	44	6.9	10.8
812	137	18	21	58	28	19	6.9	11.5
813	137	14	41	58	26	54	6.9	10.8
814	137	8	50	58	24	43	6.9	10.8
815	137	5	25	58	22	43	6.9	12.1
816	137	1	27	58	24	4	7.2	13.5
817	136	55	27	58	22	33	7.5	15.7
818	136	53	58	58	20	19	7.2	13.8
819	136	50	16	58	18	33	6.9	12.5
820	136	46	15	58	17	7	6.9	10.5
821	136	43	41	58	15	23	6.9	10.8
822	136	42	13	58	13	36	6.9	9.8
823	136	39	49	58	12	30	6.6	8.5
824	136	35	28	58	13	8	6.6	8.5
825	136	34	21	58	16	11	6.6	8.9
826	136	21	31	58	12	40	6.6	8.9
827	136	22	31	58	8	37	6.6	8.9
828	136	26	41	58	7	6	6.6	8.5
829	136	32	9	58	5	36	6.6	8.5
830	136	33	23	58	3	23	6.6	8.2
831	136	33	30	58	1	22	6.6	8.2
832	136	32	34	57	59	3	6.6	9.5
833	136	34	3	57	57	37	6.6	9.5
834	136	34	21	57	55	7	6.6	9.2
835	136	29	26	57	52	17	6.9	10.5
836	136	25	21	57	49	27	6.9	11.5
837	136	20	23	57	47	28	7.2	13.1
838	136	16	45	57	43	42	7.2	13.8
839	136	15	54	57	40	49	7.2	12.1
840	136	13	49	57	38	56	7.2	12.8

(Continued)

Table 1 (Continued)

Gage Number	Longitude deg	Longitude min	Longitude sec	Latitude deg	Latitude min	Latitude sec	100-Year Elevation ft	500-Year Elevation ft
841	136	7	51	57	36	55	7.2	11.5
842	136	5	27	57	35	47	7.5	14.8
843	136	2	48	57	34	2	7.5	14.8
844	136	1	52	57	30	37	7.2	12.8
845	135	59	46	57	29	10	6.9	10.8
846	135	57	54	57	27	15	6.9	10.8
847	135	53	41	57	25	38	7.2	12.8
848	135	50	16	57	22	56	7.2	11.5
849	135	41	18	57	20	59	7.2	12.1
850	135	45	13	57	20	4	7.2	11.5
851	135	50	39	57	19	44	7.2	11.8
852	135	50	18	57	17	17	7.2	12.5
853	135	50	57	57	15	13	7.2	12.8
854	135	51	55	57	12	46	7.2	12.8
855	135	49	47	57	10	22	7.2	12.8
856	135	46	30	57	6	11	6.9	12.1
857	135	50	39	57	4	22	6.9	11.8
858	135	51	3	57	1	11	6.9	11.2
859	135	49	20	56	58	56	6.9	9.2
860	135	44	15	56	59	47	6.9	9.5
861	135	38	8	57	0	11	6.9	10.5
862	135	36	18	57	2	10	8.2	17.4
863	135	34	57	57	4	37	9.2	20.0
864	135	33	32	57	7	35	10.2	24.3
865	135	29	12	57	9	19	10.2	24.6
866	135	23	54	57	8	12	9.8	23.3
867	135	23	15	57	6	45	9.8	22.6
868	135	23	50	57	5	28	8.9	19.7
869	135	21	46	57	3	29	7.9	16.4
870	135	17	52	57	0	19	7.5	14.4
871	135	23	1	56	58	33	7.5	12.8
872	135	23	58	56	56	40	7.5	12.8
873	135	22	37	56	53	7	7.2	12.5
874	135	22	57	56	50	44	7.2	11.8
875	135	18	23	56	46	16	7.5	14.8
876	135	18	30	56	43	36	7.5	13.1
877	135	16	30	56	41	40	7.2	12.1
878	135	12	23	56	39	60	7.9	15.1
879	135	8	59	56	38	31	8.2	17.4
880	135	8	6	56	36	19	7.9	15.7

(Continued)

Table 1 (Continued)

Gage Number	Longitude deg	Longitude min	Longitude sec	Latitude deg	Latitude min	Latitude sec	100-Year Elevation ft	500-Year Elevation ft
881	135	3	21	56	33	53	7.5	14.4
882	135	3	31	56	31	31	7.5	12.5
883	135	1	18	56	29	13	7.2	11.8
884	134	59	3	56	26	35	7.5	12.8
885	134	56	28	56	24	24	7.2	12.8
886	134	55	3	56	21	46	7.2	12.1
887	134	53	51	56	19	9	7.2	13.1
888	134	50	17	56	18	38	7.5	14.1
889	134	49	48	56	16	40	7.2	12.5
890	134	48	16	56	14	20	6.9	10.2
891	134	44	2	56	12	39	6.6	8.9
892	134	42	19	56	10	42	6.6	8.2
893	134	39	56	56	9	52	6.6	8.2
894	134	39	15	56	12	49	6.6	8.5
895	134	16	6	56	14	23	6.6	9.2
896	134	15	9	56	11	10	6.6	9.2
897	134	15	22	56	7	49	6.9	9.5
898	134	13	40	56	4	2	6.9	9.8
899	134	10	15	56	2	20	6.9	9.5
900	134	8	23	56	0	32	6.9	10.2
901	134	6	40	56	1	52	6.6	8.2
902	134	20	6	55	55	30	7.2	12.1
903	134	9	37	55	55	15	6.9	10.5
904	134	12	41	55	52	2	6.6	8.9
905	134	19	28	55	50	9	6.9	9.8
906	133	56	36	55	53	42	6.6	9.2
907	133	53	28	55	56	12	6.6	8.2
908	133	50	31	55	53	29	6.6	8.9
909	133	53	16	55	50	45	6.6	8.5
910	133	45	49	56	0	0	6.6	8.5
911	133	40	34	56	4	36	6.9	10.2
912	133	59	36	56	4	57	6.6	8.5
913	133	43	25	55	54	5	6.6	9.2
914	133	34	31	55	58	24	7.2	13.1
915	133	30	11	55	57	4	7.5	15.1
916	133	21	36	55	50	44	7.5	15.1
917	133	31	2	55	49	15	7.5	14.1
918	133	35	15	55	49	60	6.9	10.8
919	133	39	26	55	49	22	6.9	9.5
920	133	40	8	55	48	4	6.6	9.2

(Continued)

Table 1 (Continued)

Gage Number	Longitude deg	Longitude min	Longitude sec	Latitude deg	Latitude min	Latitude sec	100-Year Elevation ft	500-Year Elevation ft
921	133	41	17	55	46	35	6.9	9.8
922	133	38	36	55	43	45	6.9	9.8
923	133	31	41	55	41	44	7.5	13.8
924	133	24	45	55	40	9	7.5	15.4
925	133	23	44	55	37	56	7.5	15.4
926	133	45	1	55	32	58	7.2	13.5
927	133	49	13	55	27	18	7.5	13.5
928	133	40	35	55	22	31	7.2	11.2
929	133	39	39	55	16	30	6.9	9.2
930	133	36	26	55	14	28	6.6	9.2
931	133	32	29	55	20	10	6.9	10.5
932	133	25	58	55	19	46	7.2	11.5
933	133	14	59	55	22	17	7.2	12.1
934	133	7	21	55	27	44	7.5	15.1
935	133	9	33	55	32	42	8.2	17.1
936	133	14	22	55	35	7	8.9	20.0
937	133	28	2	55	15	32	6.9	9.2
938	133	22	17	55	13	31	6.9	10.2
939	133	15	34	55	13	9	6.9	11.5
940	133	14	11	55	11	1	6.9	11.2
941	133	13	43	55	7	39	6.9	10.8
942	133	13	20	55	4	42	6.9	10.8
943	133	9	58	54	58	58	6.9	11.5
944	133	6	59	54	55	33	7.2	14.4
945	133	3	36	54	53	49	7.2	13.5
946	133	1	52	54	51	22	6.9	11.5
947	132	59	9	54	49	7	6.9	10.5
948	132	55	2	54	46	56	6.9	10.5
949	132	52	50	54	44	31	6.6	9.5
950	132	50	24	54	41	27	6.6	8.9
951	132	45	56	54	40	35	6.6	7.9
952	132	41	7	54	39	51	6.6	7.9
953	132	41	58	54	43	49	6.6	7.9
954	132	36	34	54	46	0	6.6	8.2
955	132	20	8	54	46	55	10.2	11.5
956	132	18	4	54	43	12	10.2	11.2
957	132	13	44	54	43	11	10.2	11.2
958	132	9	57	54	41	24	10.2	11.2
959	132	5	32	54	40	55	10.2	10.8
960	132	0	52	54	41	23	10.2	10.8

(Continued)

Table 1 (Continued)

Gage Number	Longitude deg	Longitude min	Longitude sec	Latitude deg	Latitude min	Latitude sec	100-Year Elevation ft	500-Year Elevation ft
961	131	59	52	54	45	59	10.2	10.8
962	131	57	54	54	49	56	10.2	10.8
963	131	59	11	54	52	22	10.2	10.8
964	131	58	46	54	54	14	10.2	10.8
965	131	58	6	54	56	54	10.2	10.8
966	131	58	54	54	59	37	10.2	10.8
967	131	58	38	55	1	53	10.2	10.8
968	132	0	31	55	7	3	10.2	10.8
969	131	58	42	55	11	23	10.2	10.8
970	131	49	18	55	10	46	10.2	10.8
971	131	45	14	55	7	37	10.2	10.8
972	131	43	22	55	10	7	10.2	10.8
973	131	40	17	55	14	43	10.2	11.2
974	131	38	23	55	16	33	10.2	11.2
975	131	35	57	55	17	55	10.2	11.2
976	131	33	9	55	17	23	10.2	11.2
977	152	20	5	58	34	16	7.9	17.4
978	152	22	28	58	31	38	8.9	20.7
979	152	25	6	58	28	34	8.5	19.4
980	152	27	52	58	27	40	9.2	21.0
981	152	33	29	58	27	55	7.5	15.4
982	152	38	42	58	29	57	6.6	12.1
983	152	38	52	58	32	37	6.6	11.2
984	152	36	30	58	35	17	6.6	10.5
985	152	32	37	58	35	38	6.6	10.5
986	152	26	46	58	36	27	6.6	11.2
987	152	19	50	58	36	49	6.6	12.1
988	152	18	5	58	24	43	8.5	19.4
989	152	13	6	58	22	5	8.9	21.0
990	152	6	54	58	22	23	9.8	24.0
991	152	6	40	58	18	35	11.5	29.9
992	152	6	16	58	15	25	12.1	32.5
993	151	59	42	58	19	39	10.2	25.9
994	151	57	58	58	17	32	9.5	23.0
995	151	57	51	58	15	18	9.2	23.6
996	151	48	1	58	14	27	8.9	20.0
997	151	48	20	58	10	51	8.5	21.7
998	151	52	39	58	9	41	9.2	23.6
999	151	58	37	58	12	33	9.2	24.0
1000	152	3	1	58	9	38	9.2	24.3

(Continued)

Table 1 (Continued)

Gage Number	Longitude deg	Longitude min	Longitude sec	Latitude deg	Latitude min	Latitude sec	100-Year Elevation ft	500-Year Elevation ft
1001	152	5	31	58	8	9	10.8	29.5
1002	152	8	25	58	9	12	11.5	31.5
1003	152	13	5	58	10	42	12.8	36.4
1004	152	16	25	58	13	32	13.8	40.0
1005	152	17	11	58	11	1	15.1	44.0
1006	152	17	18	58	7	52	12.1	33.8
1007	152	16	52	58	6	35	11.2	29.9
1008	152	20	25	58	5	16	10.5	25.9
1009	152	25	31	58	6	49	11.2	28.2
1010	152	32	30	58	4	16	15.4	45.3
1011	152	33	37	58	8	12	17.4	51.2
1012	152	35	46	58	9	59	17.4	51.8
1013	152	36	7	58	7	3	15.7	45.6
1014	152	38	57	58	3	23	14.8	41.0
1015	152	45	14	58	0	45	17.7	52.5
1016	152	44	11	57	55	44	17.1	50.2
1017	152	50	45	57	51	21	27.6	83.0
1018	152	54	23	57	44	57	31.8	94.8
1019	152	50	54	57	47	51	29.9	89.9
1020	152	47	7	57	50	41	26.6	80.1
1021	152	40	26	57	51	58	18.7	56.1
1022	152	36	47	57	54	30	16.1	45.6
1023	152	25	38	57	57	27	16.4	47.6
1024	152	21	59	57	52	18	9.5	22.6
1025	152	19	49	57	48	23	9.2	21.7
1026	152	28	51	57	44	33	9.5	23.6
1027	152	26	34	57	42	36	9.5	23.0
1028	152	23	42	57	40	13	9.5	22.6
1029	152	26	33	57	34	49	9.8	24.3
1030	152	19	38	57	37	16	8.5	19.7
1031	152	14	59	57	36	12	8.5	20.0
1032	152	9	18	57	36	18	7.9	17.7
1033	152	9	30	57	34	40	8.2	18.7
1034	152	12	27	57	32	47	10.5	25.9
1035	152	16	36	57	30	48	11.2	30.2
1036	152	18	57	57	28	36	11.5	31.5
1037	152	19	31	57	25	28	11.5	30.8
1038	152	21	15	57	24	53	10.5	28.9
1039	152	26	41	57	25	30	10.8	29.5
1040	152	31	37	57	25	38	11.2	30.5

(Continued)

Table 1 (Continued)

Gage Number	Longitude deg	Longitude min	Longitude sec	Latitude deg	Latitude min	Latitude sec	100-Year Elevation ft	500-Year Elevation ft
1041	152	38	51	57	27	22	14.8	39.7
1042	152	48	7	57	29	2	17.1	49.9
1043	152	53	27	57	29	48	21.0	62.3
1044	152	52	36	57	27	35	20.0	60.4
1045	152	48	0	57	27	21	19.0	56.1
1046	152	43	27	57	25	20	15.4	43.0
1047	152	39	29	57	23	41	12.1	31.2
1048	152	36	31	57	21	17	9.8	24.6
1049	152	38	18	57	18	32	9.2	22.3
1050	152	42	15	57	16	6	9.8	25.6
1051	152	48	57	57	15	27	10.2	25.6
1052	152	52	46	57	16	48	12.1	33.5
1053	152	57	50	57	19	5	14.4	42.3
1054	153	5	3	57	18	34	15.4	45.6
1055	153	8	25	57	18	37	17.7	52.5
1056	153	7	33	57	17	15	17.1	50.2
1057	152	59	20	57	16	47	14.4	42.3
1058	152	56	30	57	14	57	11.2	29.9
1059	152	58	56	57	13	42	10.2	25.6
1060	153	1	60	57	12	54	11.2	28.9
1061	153	6	42	57	12	3	11.8	30.2
1062	153	11	6	57	12	40	12.5	33.1
1063	153	14	58	57	13	5	13.8	37.1
1064	153	19	1	57	11	9	16.1	44.9
1065	153	21	45	57	9	32	16.1	44.6
1066	153	24	25	57	8	14	15.4	43.0
1067	153	26	35	57	6	32	14.4	38.7
1068	153	21	51	57	7	3	14.1	38.4
1069	153	19	20	57	8	46	16.1	45.6
1070	153	14	4	57	11	54	13.1	34.1
1071	153	9	40	57	10	29	12.1	31.5
1072	153	3	37	57	10	34	11.2	28.9
1073	152	56	34	57	10	26	10.2	25.3
1074	152	52	10	57	8	30	9.2	21.3
1075	152	55	52	57	6	54	9.2	21.0
1076	153	1	5	57	6	52	9.2	20.7
1077	153	4	23	57	5	59	10.2	24.9
1078	153	7	2	57	4	60	10.2	26.9
1079	153	12	46	57	4	4	11.8	33.5
1080	153	12	26	57	1	18	10.2	25.9

(Continued)

Table 1 (Continued)

Gage Number	Longitude deg	Longitude min	Longitude sec	Latitude deg	Latitude min	Latitude sec	100-Year Elevation ft	500-Year Elevation ft
1081	153	14	7	56	59	44	9.2	22.3
1082	153	18	33	56	59	5	7.9	16.7
1083	153	19	15	57	1	20	12.1	31.2
1084	153	23	28	57	3	11	13.5	35.1
1085	153	29	53	57	3	26	12.8	33.5
1086	153	33	48	57	4	49	13.8	36.4
1087	153	39	19	57	4	31	15.1	40.4
1088	153	34	33	57	1	47	13.5	34.8
1089	153	32	45	56	58	49	10.8	25.9
1090	153	35	44	56	55	36	7.5	16.7
1091	153	39	45	56	55	23	8.2	18.4
1092	153	41	47	56	53	57	8.2	19.0
1093	153	40	49	56	51	44	8.2	17.7
1094	153	44	51	56	50	10	8.2	17.4
1095	153	50	15	56	49	39	8.9	20.7
1096	153	51	51	56	47	39	7.9	17.1
1097	153	54	5	56	45	48	7.5	16.1
1098	153	58	9	56	44	14	7.5	16.1
1099	154	6	10	56	44	19	6.6	12.1
1100	154	8	13	56	45	11	6.2	9.5
1101	154	6	3	56	47	29	6.2	9.5
1102	154	3	30	56	50	31	6.2	9.8
1103	153	58	60	56	52	34	6.2	9.2
1104	153	54	58	56	54	27	6.2	9.2
1105	153	50	16	56	56	23	6.6	10.8
1106	153	51	15	56	57	50	6.6	11.2
1107	153	54	21	56	57	4	6.6	10.2
1108	153	58	2	56	57	40	6.2	9.2
1109	153	56	39	57	0	35	6.6	10.8
1110	153	48	51	57	5	39	6.6	12.5
1111	153	49	4	57	7	43	6.6	12.8
1112	153	57	38	57	3	28	6.6	12.1
1113	154	5	16	56	57	33	6.6	10.5
1114	154	5	37	57	5	0	6.6	11.5
1115	154	9	12	57	6	40	6.6	12.8
1116	154	17	20	57	6	16	6.9	13.5
1117	154	23	28	57	2	54	6.9	14.1
1118	154	24	34	57	6	41	6.9	14.1
1119	154	19	2	57	8	17	6.9	13.8
1120	154	11	57	57	8	24	6.9	13.1

(Continued)

Table 1 (Continued)

Gage Number	Longitude deg	Longitude min	Longitude sec	Latitude deg	Latitude min	Latitude sec	100-Year Elevation ft	500-Year Elevation ft
1121	154	3	54	57	6	46	6.6	12.5
1122	154	9	22	56	56	24	6.2	9.5
1123	154	9	49	56	54	34	6.2	9.2
1124	154	13	25	56	52	8	6.6	10.2
1125	154	17	40	56	50	17	6.2	9.8
1126	154	18	22	56	54	21	6.2	10.5
1127	154	20	52	56	55	52	6.6	10.8
1128	154	23	5	56	57	6	6.2	10.2
1129	154	27	7	56	58	14	6.2	9.5
1130	154	31	16	56	59	46	6.2	8.5
1131	154	30	46	57	2	18	6.2	8.5
1132	154	30	44	57	4	31	6.2	8.9
1133	154	31	7	57	7	17	6.2	9.2
1134	154	31	18	57	9	25	6.2	9.5
1135	154	32	28	57	11	38	6.2	9.8
1136	154	34	2	57	13	36	10.2	12.5
1137	154	36	31	57	15	30	9.8	11.5
1138	154	43	48	57	15	47	9.8	10.8
1139	154	47	9	57	16	44	9.8	10.5
1140	154	47	28	57	20	24	9.8	10.8
1141	154	41	57	57	22	28	9.8	11.8
1142	154	42	26	57	25	9	9.8	11.8
1143	154	38	40	57	28	6	9.8	11.5
1144	154	36	22	57	30	14	9.8	11.5
1145	154	30	44	57	32	42	9.8	11.8
1146	154	25	52	57	34	8	9.8	11.8
1147	154	22	31	57	36	17	9.8	12.1
1148	154	18	22	57	37	34	10.2	12.5
1149	154	15	1	57	38	28	10.2	12.5
1150	154	11	28	57	39	9	10.2	12.8
1151	154	8	23	57	38	41	10.2	13.1
1152	154	3	47	57	38	26	10.2	13.5
1153	153	59	8	57	38	29	10.2	14.1
1154	153	58	43	57	36	45	10.5	16.7
1155	153	58	45	57	35	3	10.8	18.4
1156	153	58	4	57	33	9	11.2	20.0
1157	153	55	4	57	30	25	11.8	22.0
1158	153	54	19	57	27	51	12.5	24.0
1159	153	53	41	57	25	22	13.1	25.9
1160	153	48	18	57	20	58	14.4	30.5

(Continued)

Table 1 (Continued)

Gage Number	Longitude deg	Longitude min	Longitude sec	Latitude deg	Latitude min	Latitude sec	100-Year Elevation ft	500-Year Elevation ft
1161	153	45	33	57	19	56	14.1	29.9
1162	153	47	43	57	23	11	13.8	28.5
1163	153	51	25	57	25	47	13.1	26.2
1164	153	52	27	57	28	24	12.5	24.0
1165	153	51	55	57	31	21	11.8	22.0
1166	153	50	23	57	33	52	11.5	20.3
1167	153	52	10	57	37	24	10.8	19.0
1168	153	46	8	57	38	12	10.8	18.0
1169	153	40	6	57	37	36	11.2	19.0
1170	153	35	56	57	35	28	11.5	20.3
1171	153	36	46	57	37	58	11.5	20.7
1172	153	40	40	57	39	26	11.2	19.0
1173	153	44	10	57	40	18	10.8	18.0
1174	153	47	32	57	41	3	10.8	17.4
1175	153	50	57	57	41	33	10.5	16.7
1176	153	54	48	57	42	18	10.2	13.8
1177	153	55	25	57	44	36	10.2	13.1
1178	153	55	28	57	46	49	10.2	12.5
1179	153	53	35	57	48	39	9.8	12.1
1180	153	51	5	57	49	58	10.2	12.5
1181	153	47	29	57	51	26	10.2	12.8
1182	153	43	26	57	53	9	10.2	13.5
1183	153	40	37	57	52	17	10.2	13.8
1184	153	36	56	57	52	8	10.2	14.4
1185	153	35	33	57	49	43	10.5	16.7
1186	153	32	57	57	46	50	11.5	21.0
1187	153	33	3	57	42	40	11.5	22.0
1188	153	31	11	57	38	41	11.8	23.3
1189	153	29	54	57	44	16	11.5	22.0
1190	153	27	9	57	45	19	11.5	22.0
1191	153	16	6	57	47	59	11.5	22.0
1192	153	18	5	57	48	43	11.5	22.0
1193	153	20	35	57	50	25	11.2	21.0
1194	153	23	56	57	51	15	10.8	19.4
1195	153	27	40	57	52	22	10.5	15.7
1196	153	30	28	57	53	51	10.2	14.4
1197	153	31	7	57	55	55	10.2	13.5
1198	153	27	29	57	57	15	10.2	15.1
1199	153	23	53	57	56	1	11.5	24.9
1200	153	16	60	57	53	30	11.5	25.6

(Continued)

Table 1 (Continued)

Gage Number	Longitude deg	Longitude min	Longitude sec	Latitude deg	Latitude min	Latitude sec	100-Year Elevation ft	500-Year Elevation ft
1201	153	12	48	57	52	44	9.8	25.9
1202	153	18	4	57	58	34	9.8	26.6
1203	153	10	45	57	57	14	9.8	26.6
1204	153	6	4	57	55	47	10.8	29.2
1205	152	58	15	57	55	53	12.5	35.4
1206	152	55	9	57	55	42	14.1	40.7
1207	152	46	51	57	58	45	15.4	44.9
1208	152	52	11	57	58	20	15.1	43.6
1209	152	55	23	57	58	13	14.1	40.0
1210	152	59	33	57	58	8	12.8	35.8
1211	153	2	55	57	58	33	10.8	29.5
1212	153	8	53	58	0	38	9.8	25.9
1213	153	13	4	58	1	57	10.8	22.6
1214	153	18	48	58	1	60	10.8	21.0
1215	153	24	29	58	2	38	10.2	13.1
1216	153	20	42	58	5	6	10.2	12.8
1217	153	17	15	58	7	53	10.2	13.5
1218	153	14	7	58	6	55	10.2	14.1
1219	153	12	41	58	10	1	10.2	13.5
1220	153	9	35	58	11	51	10.2	13.8
1221	153	2	10	58	10	58	10.2	14.1
1222	153	5	9	58	15	27	10.2	14.1
1223	152	59	24	58	16	55	10.2	14.4
1224	152	55	35	58	15	57	10.5	14.8
1225	152	50	24	58	16	6	10.5	16.1
1226	152	46	55	58	15	30	10.5	16.4
1227	152	45	23	58	15	0	10.8	17.7
1228	152	46	18	58	16	41	10.8	18.0
1229	152	48	18	58	21	10	10.5	16.7
1230	152	51	38	58	22	18	10.5	14.8
1231	152	53	2	58	23	29	10.2	14.8
1232	152	48	21	58	23	19	10.2	14.8
1233	152	45	29	58	25	12	10.5	14.8
1234	152	40	2	58	27	9	10.5	14.8
1235	152	14	43	58	53	29	11.8	18.4
1236	152	20	57	58	53	43	11.8	16.1
1237	152	15	42	58	55	45	12.1	20.0
1238	152	8	58	58	55	23	12.1	22.0
1239	153	25	33	59	19	19	10.5	16.1
1240	153	32	33	59	20	33	10.8	19.7

(Continued)

Table 1 (Concluded)

Gage Number	Longitude deg	Longitude min	Longitude sec	Latitude deg	Latitude min	Latitude sec	100-Year Elevation ft	500-Year Elevation ft
1241	153	29	20	59	23	20	11.5	21.7
1242	153	23	3	59	24	5	11.2	20.7
1243	153	20	28	59	21	56	10.5	15.4
1244	151	58	31	60	21	48	11.5	12.5
1245	152	4	20	60	20	31	11.5	12.5
1246	152	0	2	60	24	30	11.5	12.5
1247	151	58	15	60	29	15	11.5	12.8
1248	151	53	6	60	30	10	11.5	13.1
1249	151	53	58	60	26	25	11.5	12.8

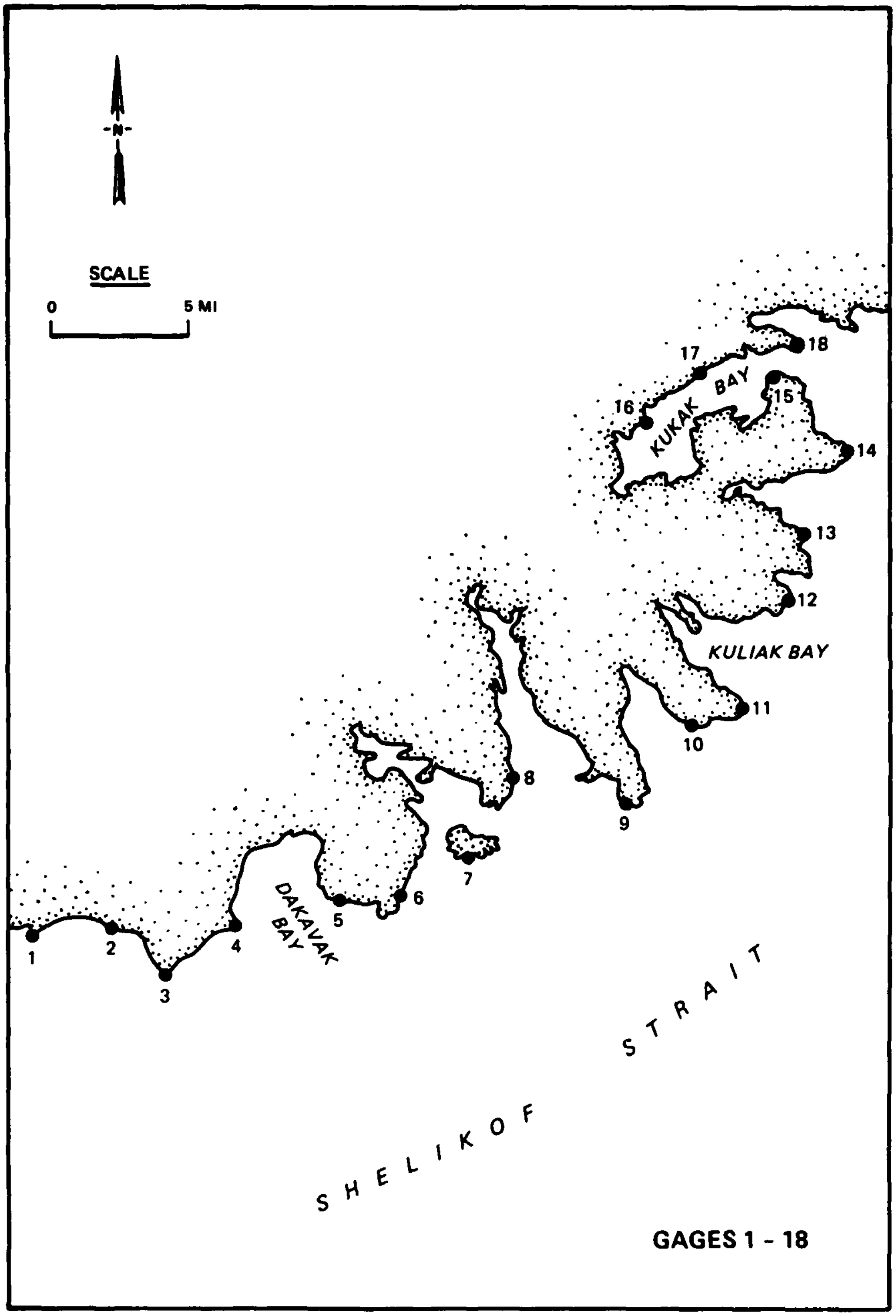

-N-
SCALE
0
5 MI
KUKAK BAY
KULIAK BAY
DAKAVAK BAY
SHELIKOF STRAIT
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
GAGES 1 - 18

PLATE 1

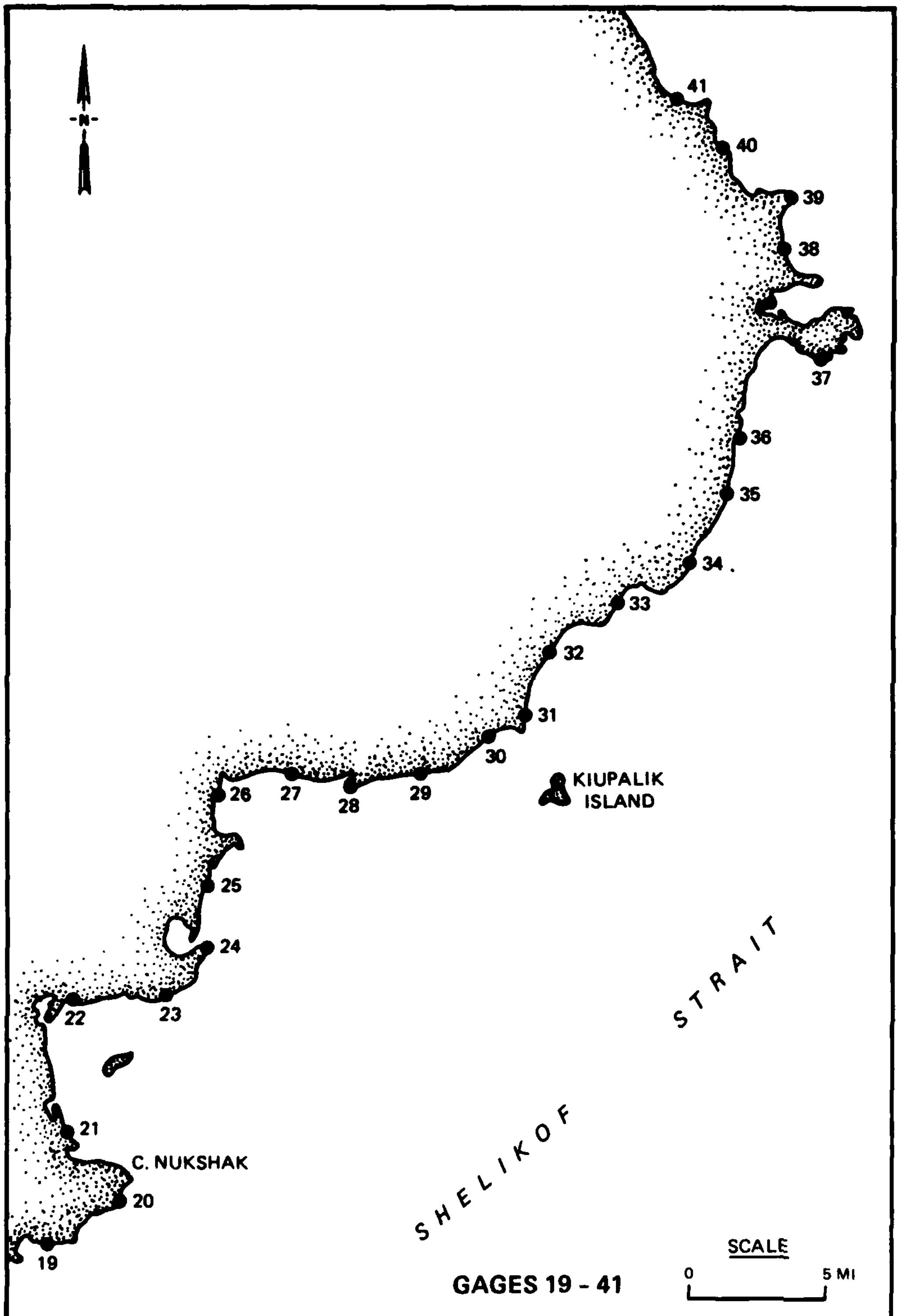

N
41
40
39
38
37
36
35
34
33
32
31
30
29
28
27
26
25
24
23
22
21
20
19
KIUPALIK
ISLAND
C. NUKSHAK
SHELIKOF STRAIT
SCALE
0
5 MI
GAGES 19 - 41

PLATE 2

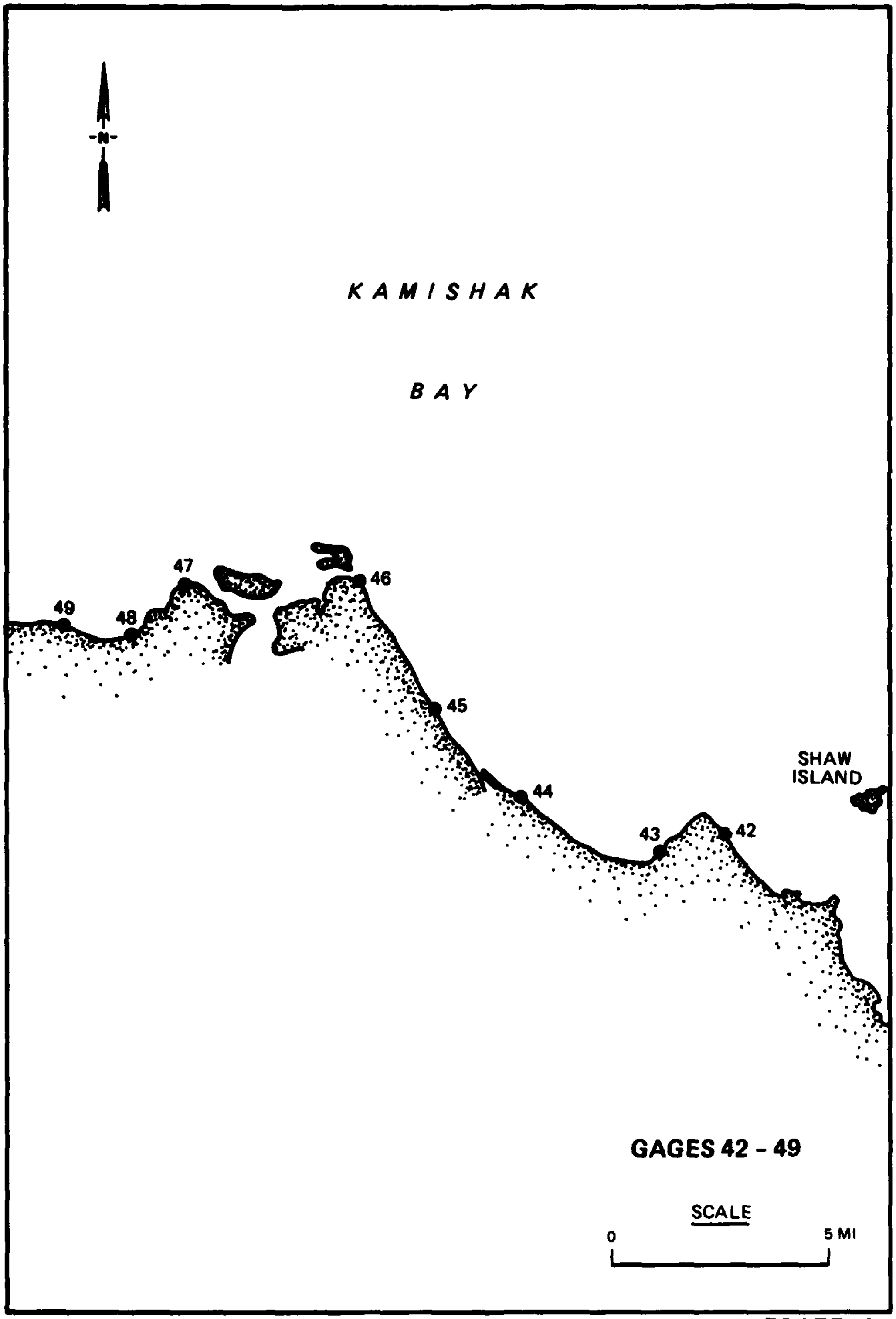

N
KAMISHAK
BAY
49
48
47
46
45
44
43
42
SHAW ISLAND
GAGES 42 - 49
SCALE
0
5 MI

PLATE 3

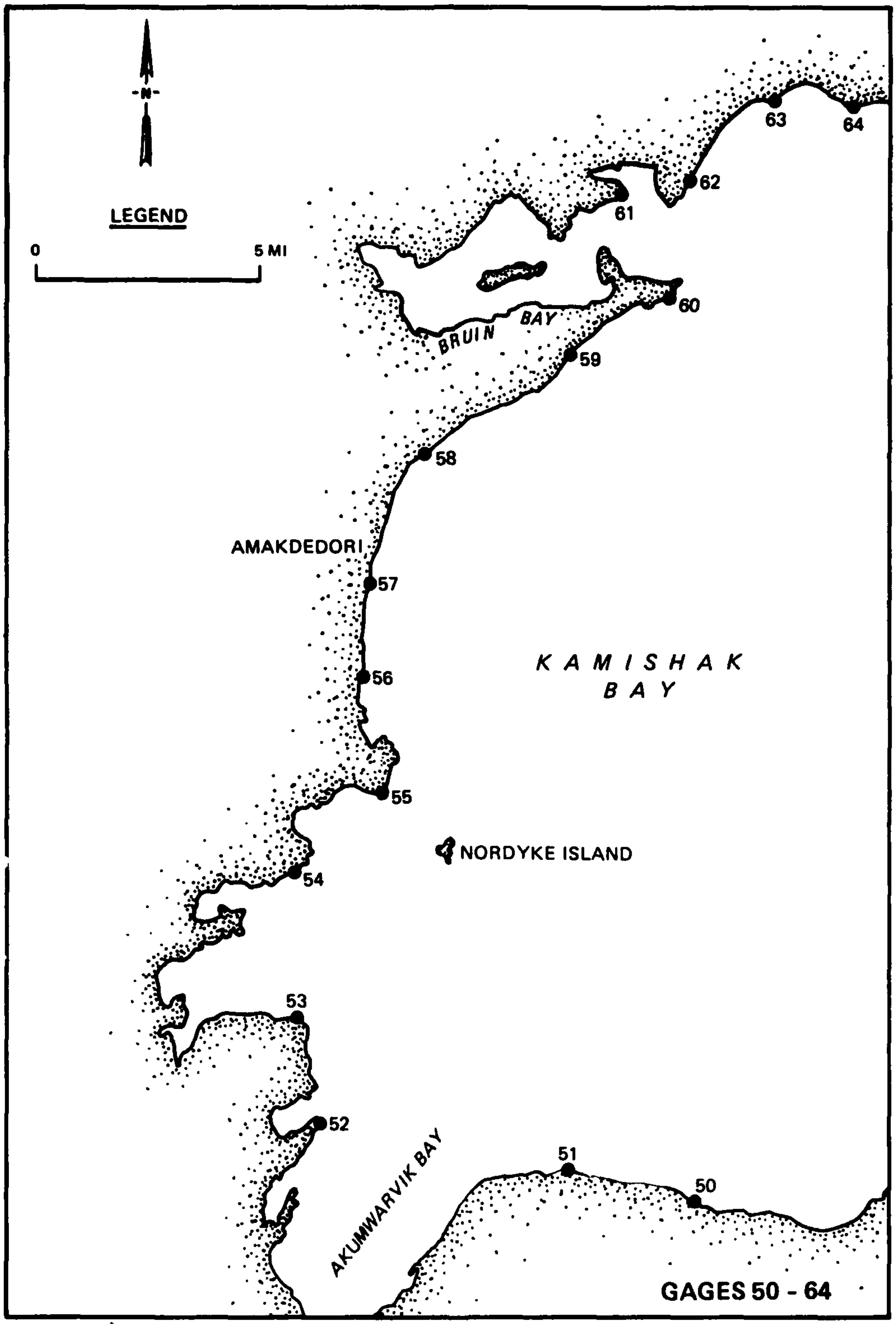
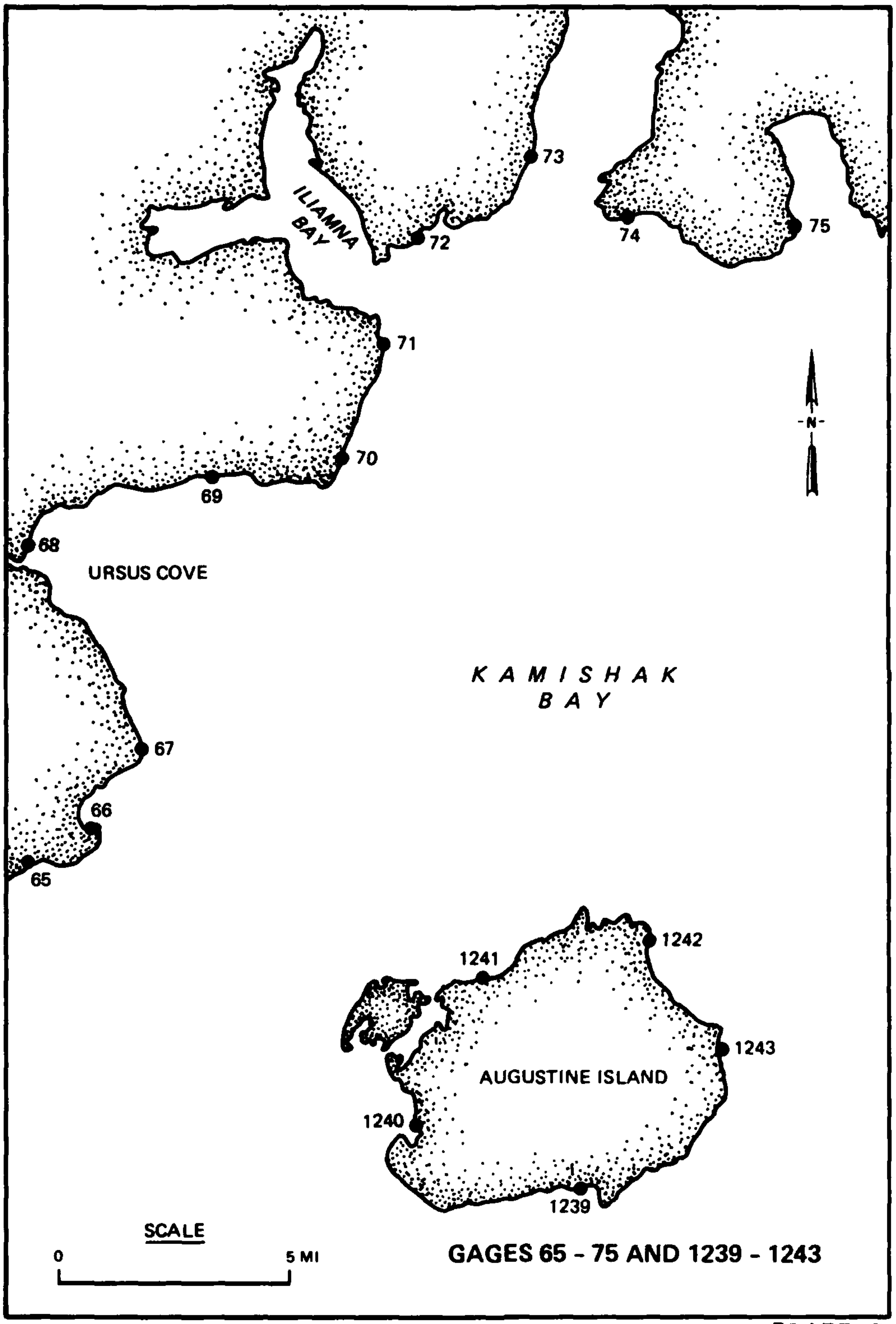

N
LEGEND
0
5 MI
BRUIN BAY
AMAKDEDORI
KAMISHAK BAY
NORDYKE ISLAND
AKUMWARVIK BAY
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
GAGES 50 - 64

PLATE 4



GAGES 65 - 75 AND 1239 - 1243

PLATE 5

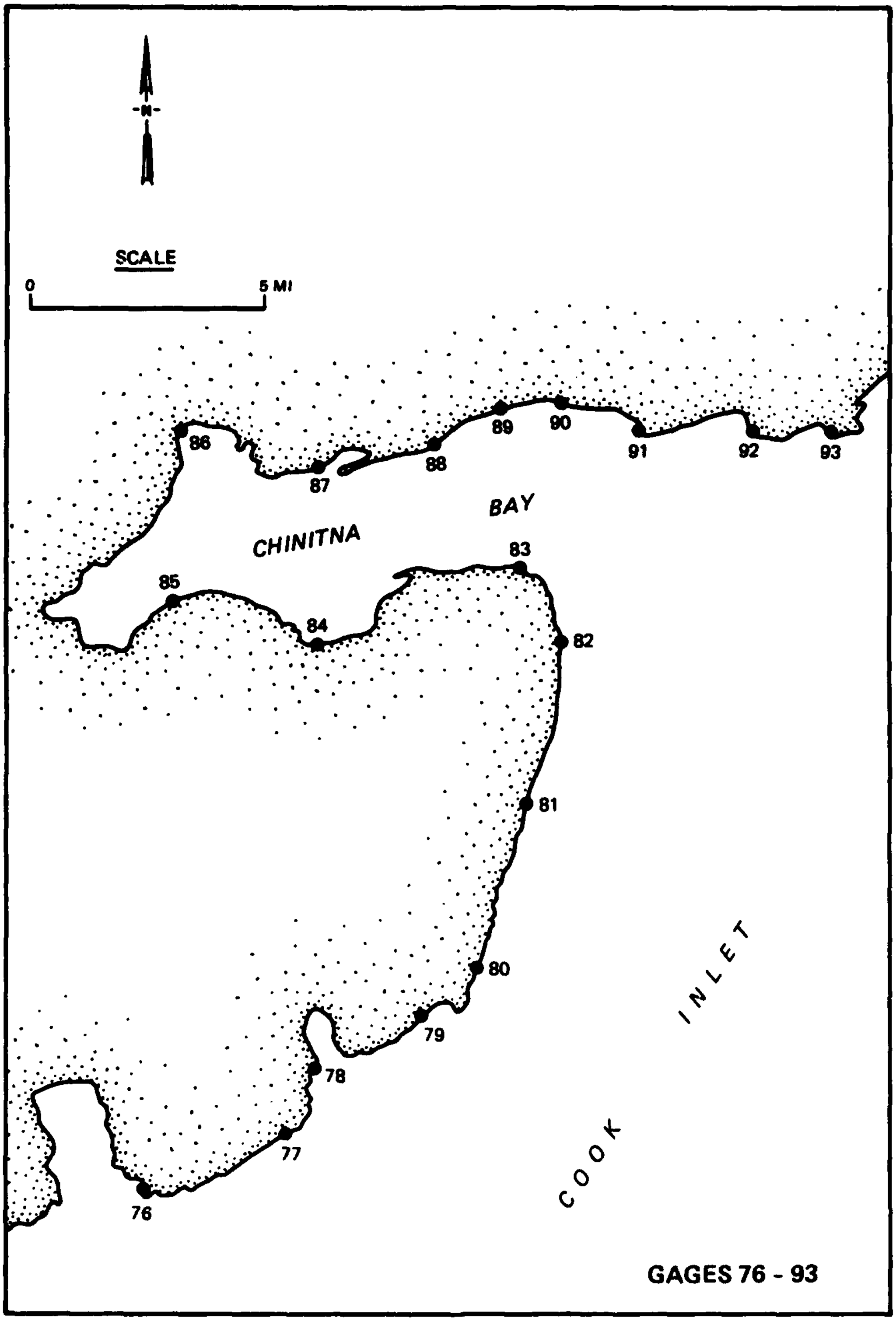

N
SCALE
0
5 MI
86
87
88
89
90
91
92
93
BAY
CHINITNA
83
85
84
82
81
80
79
78
77
76
COOK
INLET
GAGES 76 - 93

PLATE 6

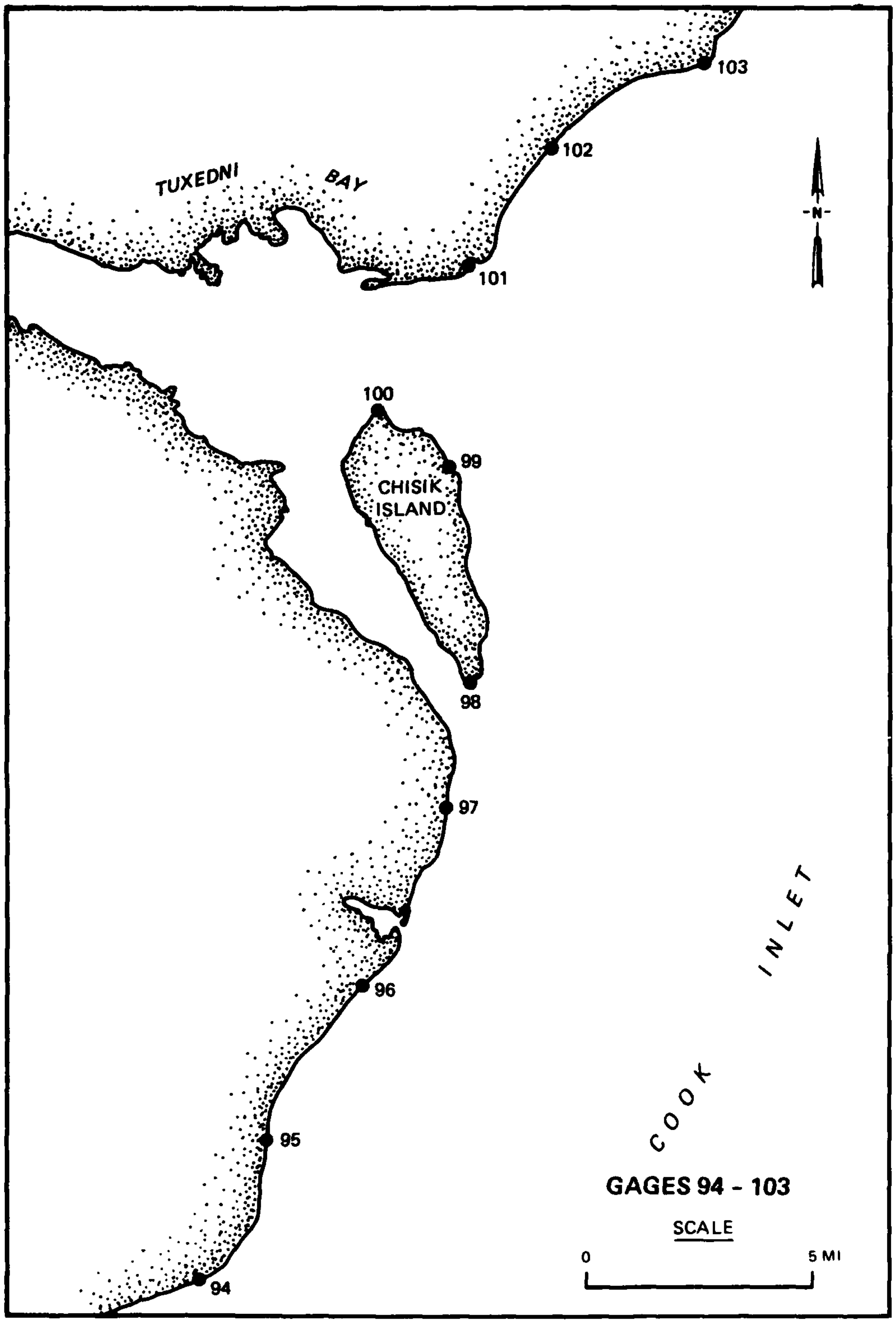

TUXEDNI BAY
103
102
101
N
100
99
CHISIK ISLAND
98
97
96
95
94
COOK INLET
GAGES 94 - 103
SCALE
0
5 MI

PLATE 7

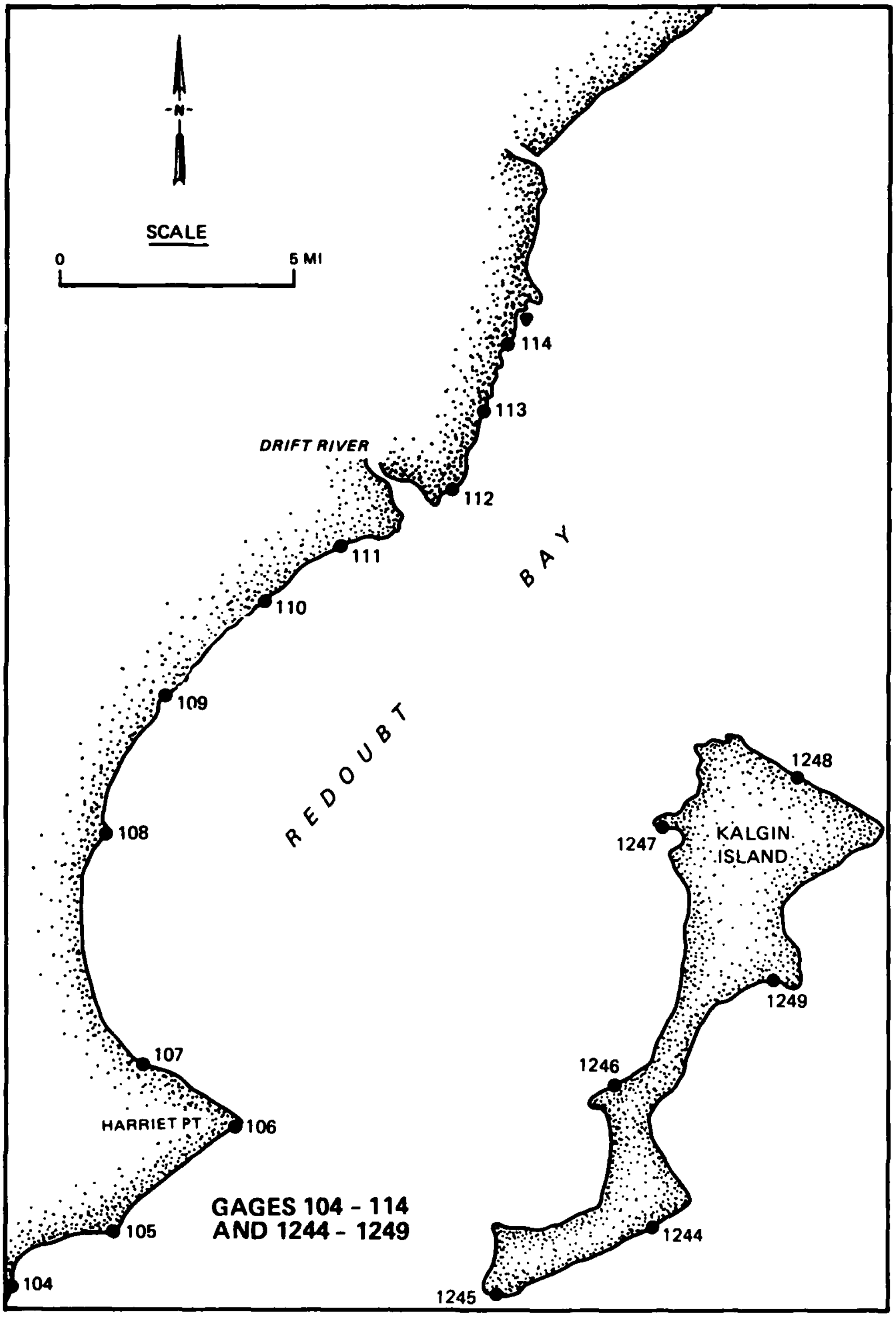
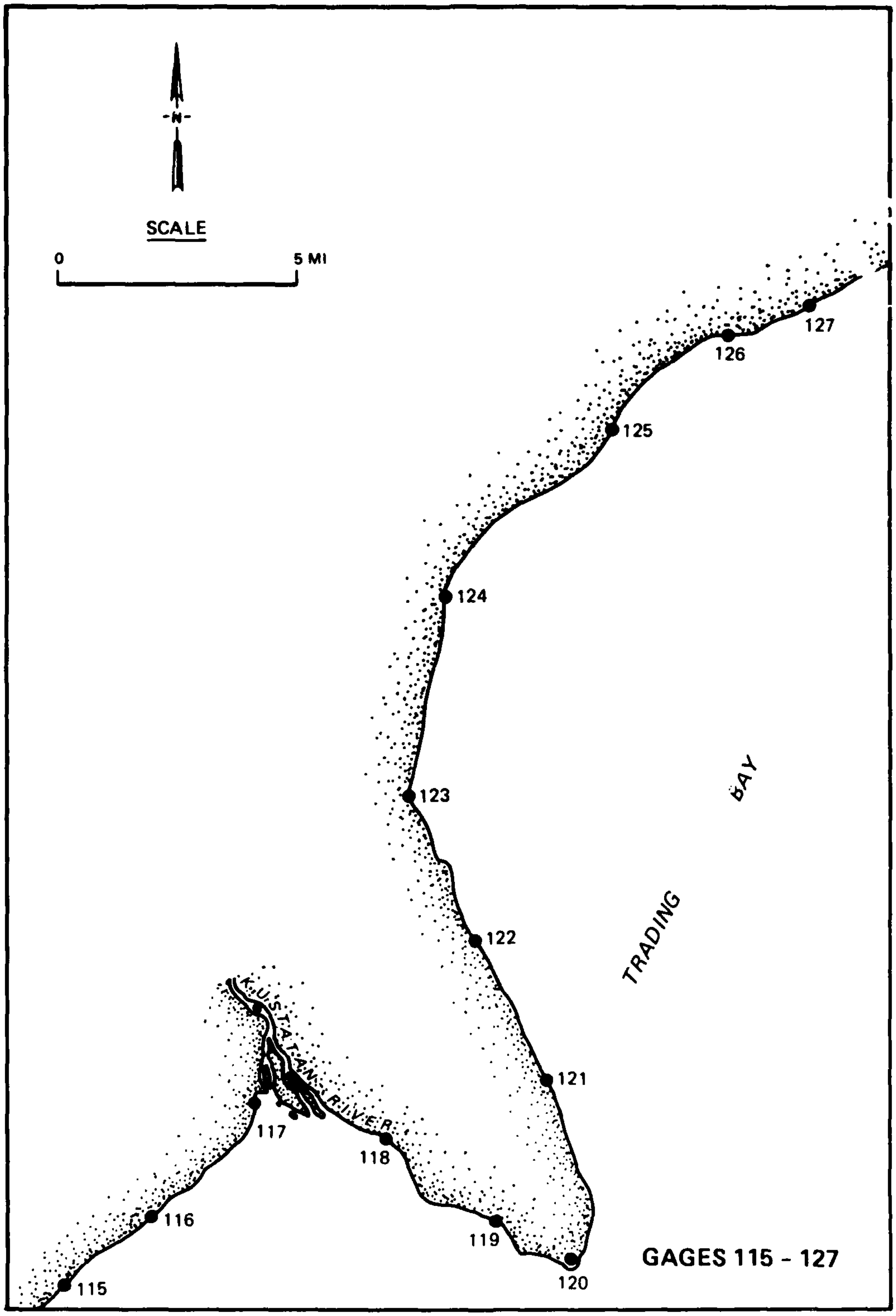

N
SCALE
0
5 MI
114
113
DRIFT RIVER
112
111
110
BAY
109
REDOUBT
108
107
HARRIET PT
106
105
104
GAGES 104 - 114
AND 1244 - 1249
1248
1247
KALGIN
ISLAND
1249
1246
1244
1245

PLATE 8



N
SCALE
0
5 MI
127
126
125
124
123
BAY
TRADING
122
KUSTATAN RIVER
121
117
118
116
119
115
120
GAGES 115 - 127

PLATE 9

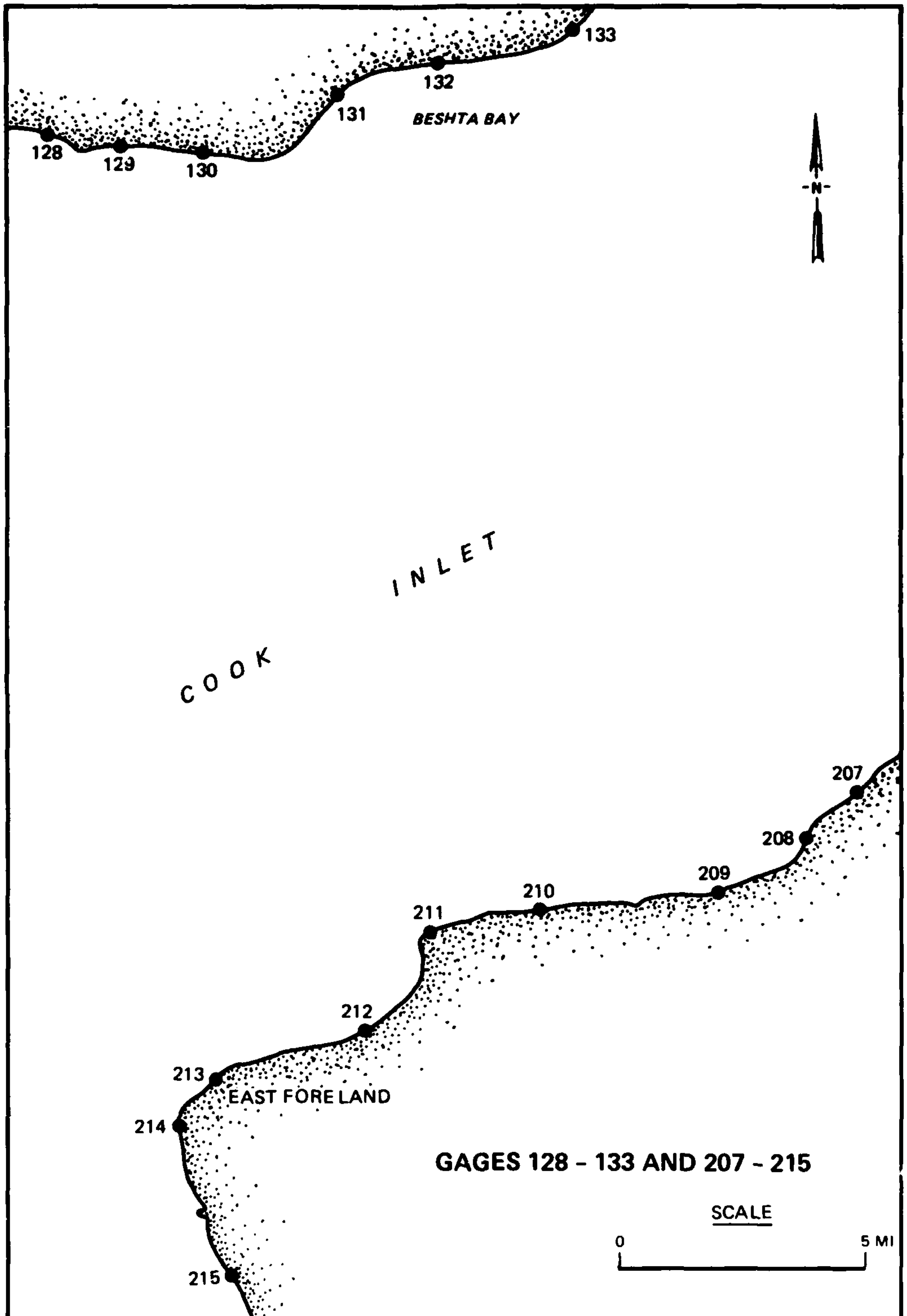

133
132
131
BESHTA BAY
128
129
130
COOK INLET
207
208
209
210
211
212
213
EAST FORE LAND
214
215
GAGES 128 - 133 AND 207 - 215
SCALE
0
5 MI

PLATE 10

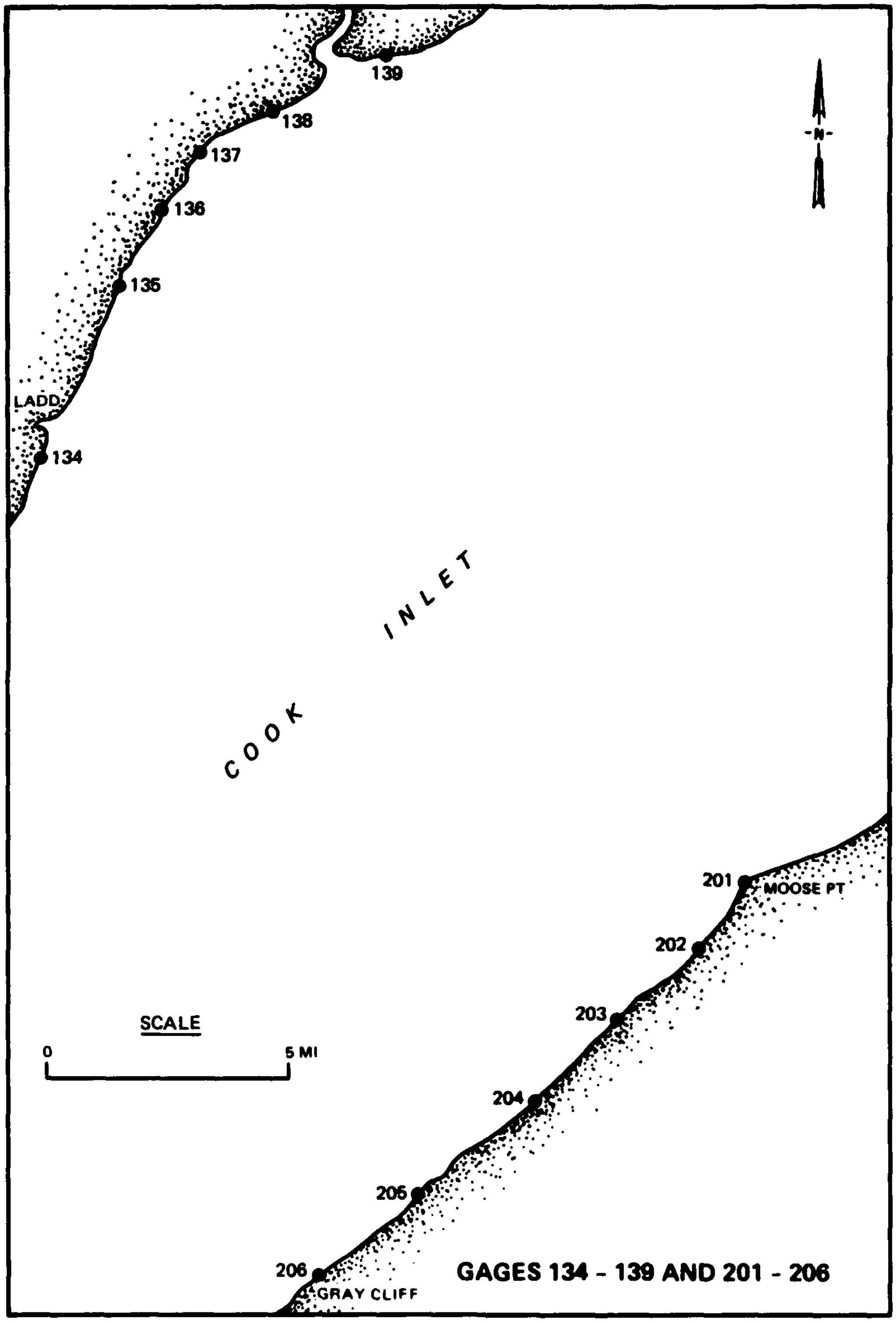

139
138
137
136
135
LADD
134
N
COOK INLET
201
MOOSE PT
202
203
204
205
206
GRAY CLIFF
SCALE
0
5 MI
GAGES 134 - 139 AND 201 - 206

PLATE 11

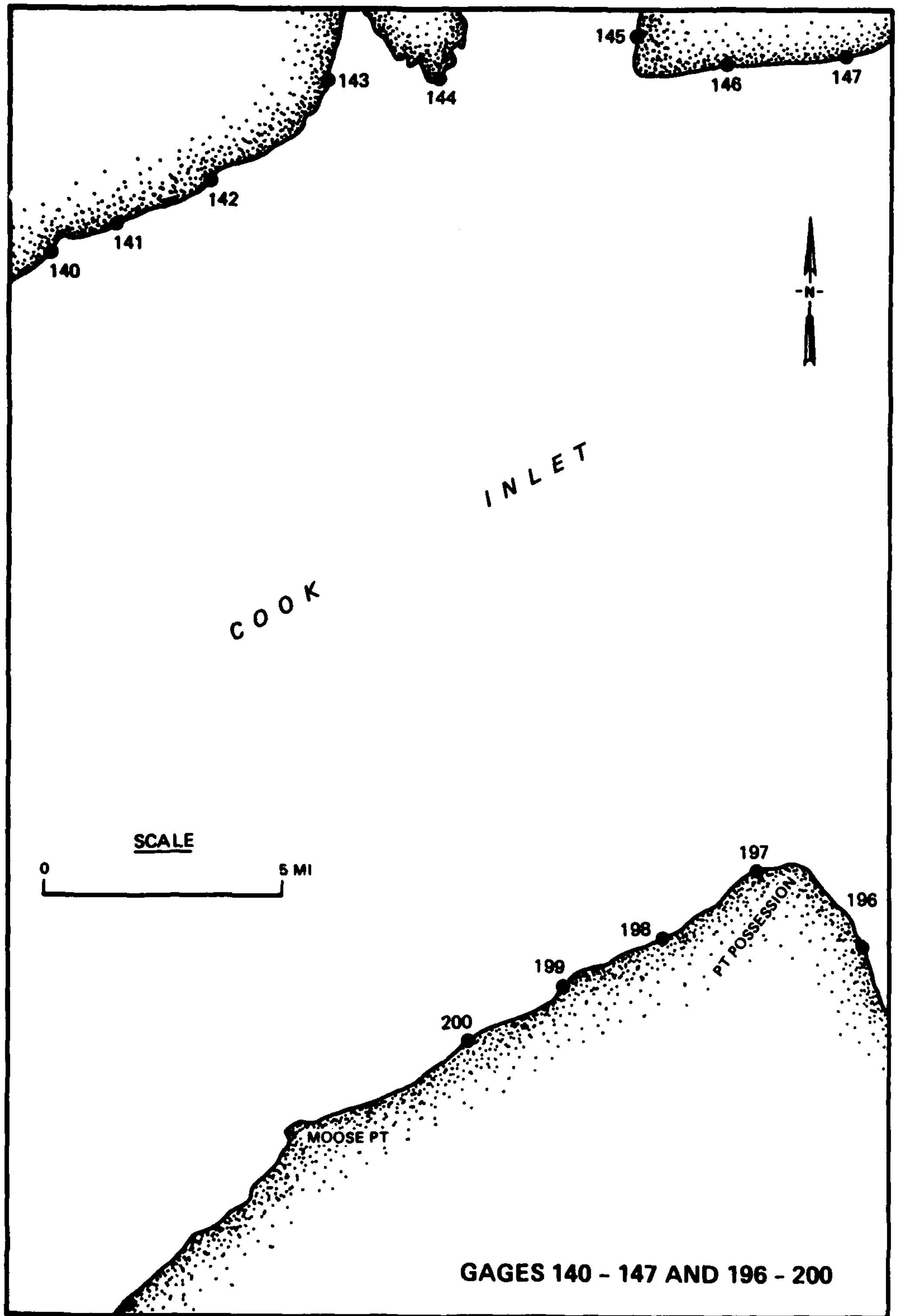

145
143
144
146
147
142
141
140
-N-
INLET
COOK
SCALE
0
5 MI
197
196
198
PT POSSESSION
199
200
MOOSE PT
GAGES 140 - 147 AND 196 - 200

PLATE 12

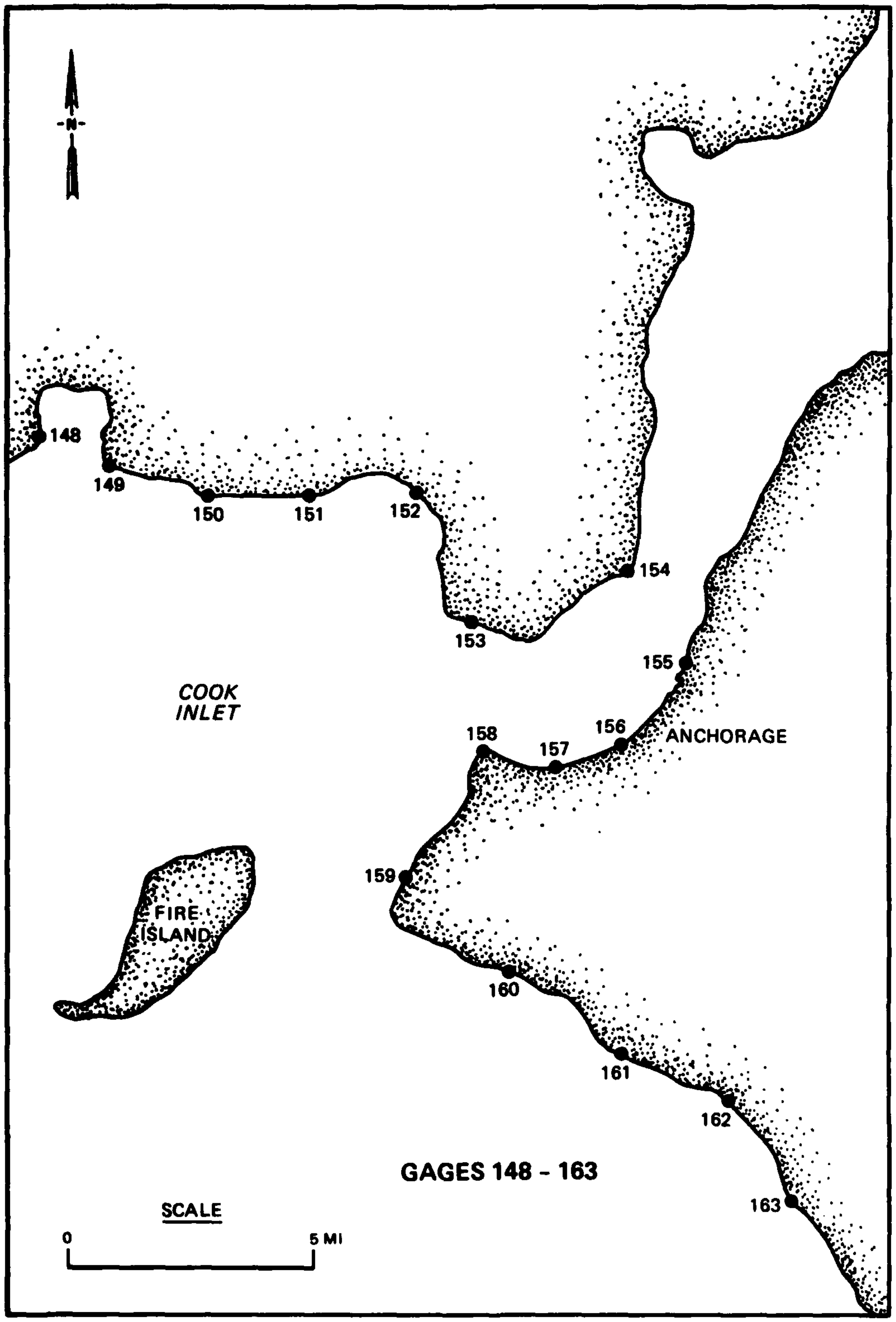

N
148
149
150
151
152
153
154
155
156
157
158
159
160
161
162
163
COOK
INLET
ANCHORAGE
FIRE
ISLAND
GAGES 148 - 163
SCALE
0
5 MI

PLATE 13

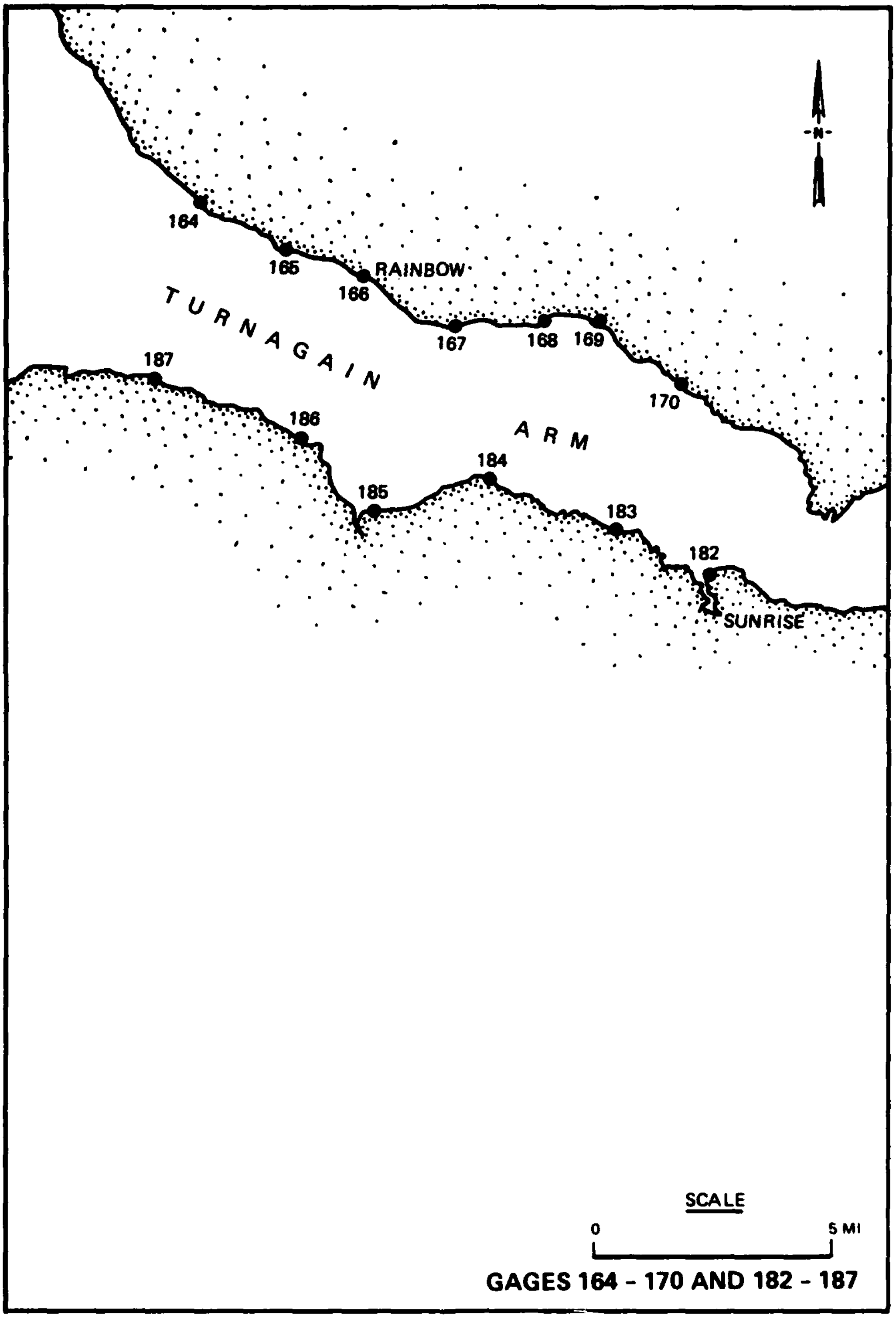

N
164
165
RAINBOW
166
TURNAGAIN
167
168
169
187
170
186
ARM
184
185
183
182
SUNRISE
SCALE
0
5 MI
GAGES 164 - 170 AND 182 - 187

PLATE 14

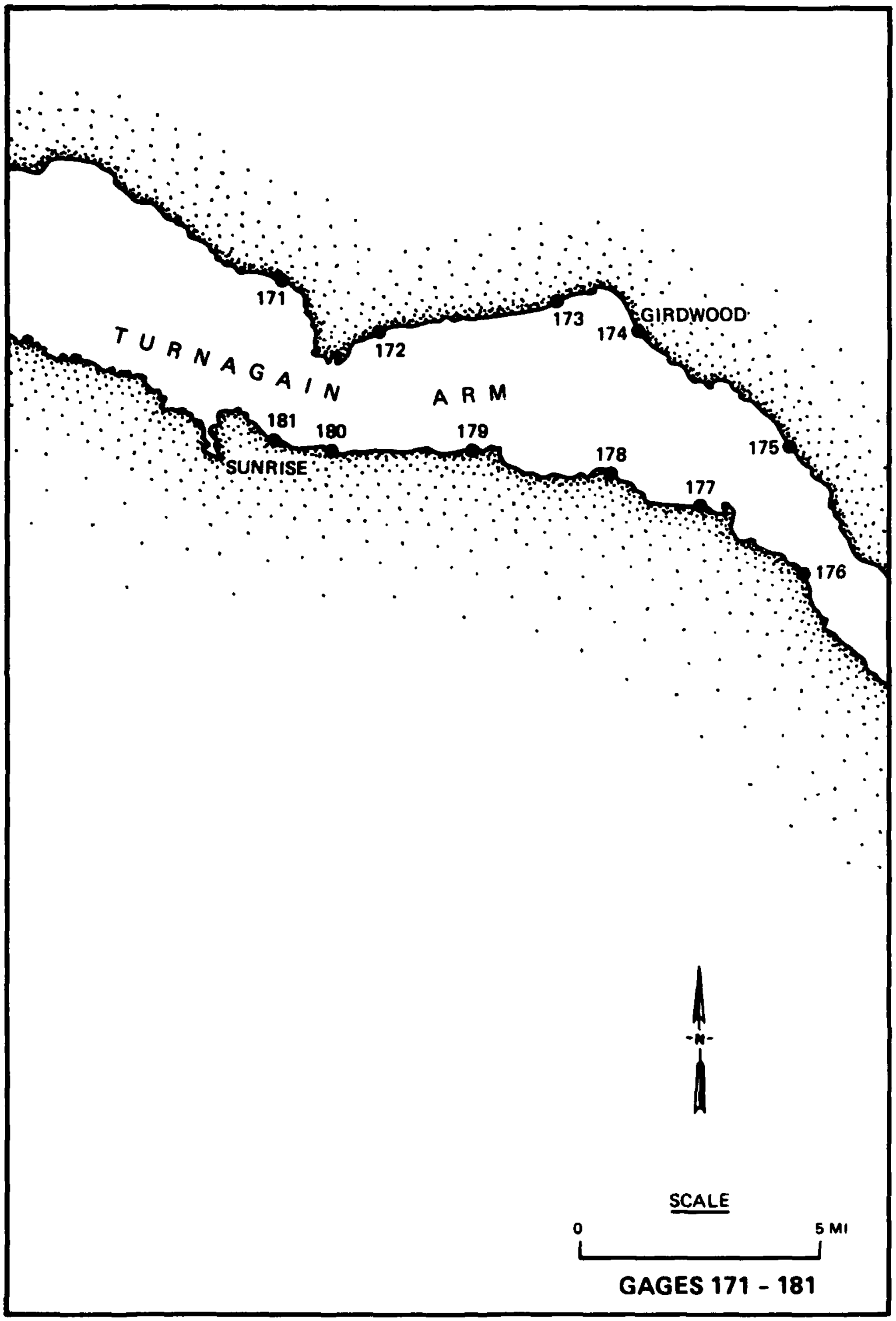

TURNAGAIN ARM
GIRDWOOD
SUNRISE
171
172
173
174
175
176
177
178
179
180
181
N
SCALE
0
5 MI
GAGES 171 - 181

PLATE 15

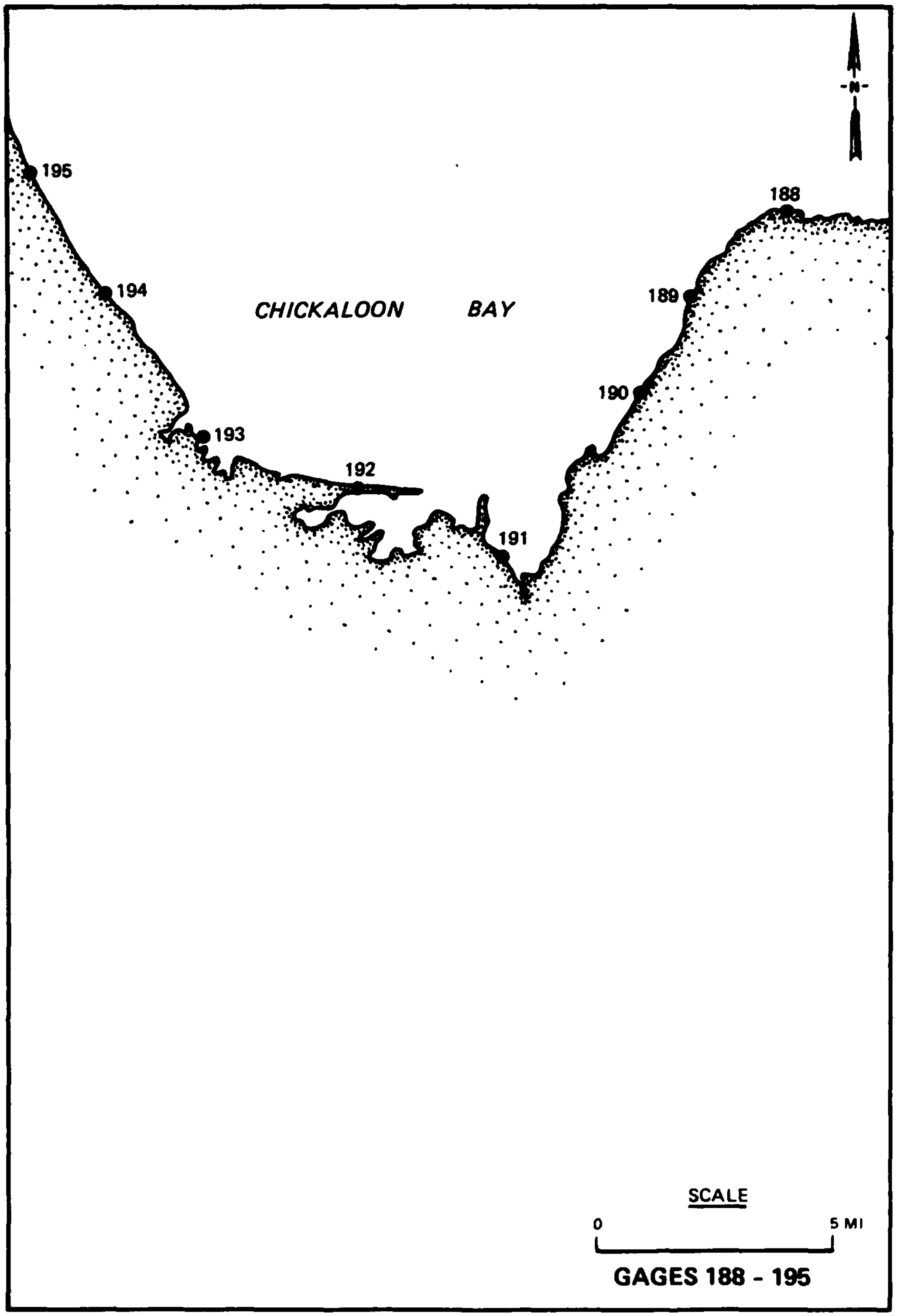

195
194
193
192
191
190
189
188
CHICKALOON BAY
N
SCALE
0
5 MI
GAGES 188 - 195

PLATE 16

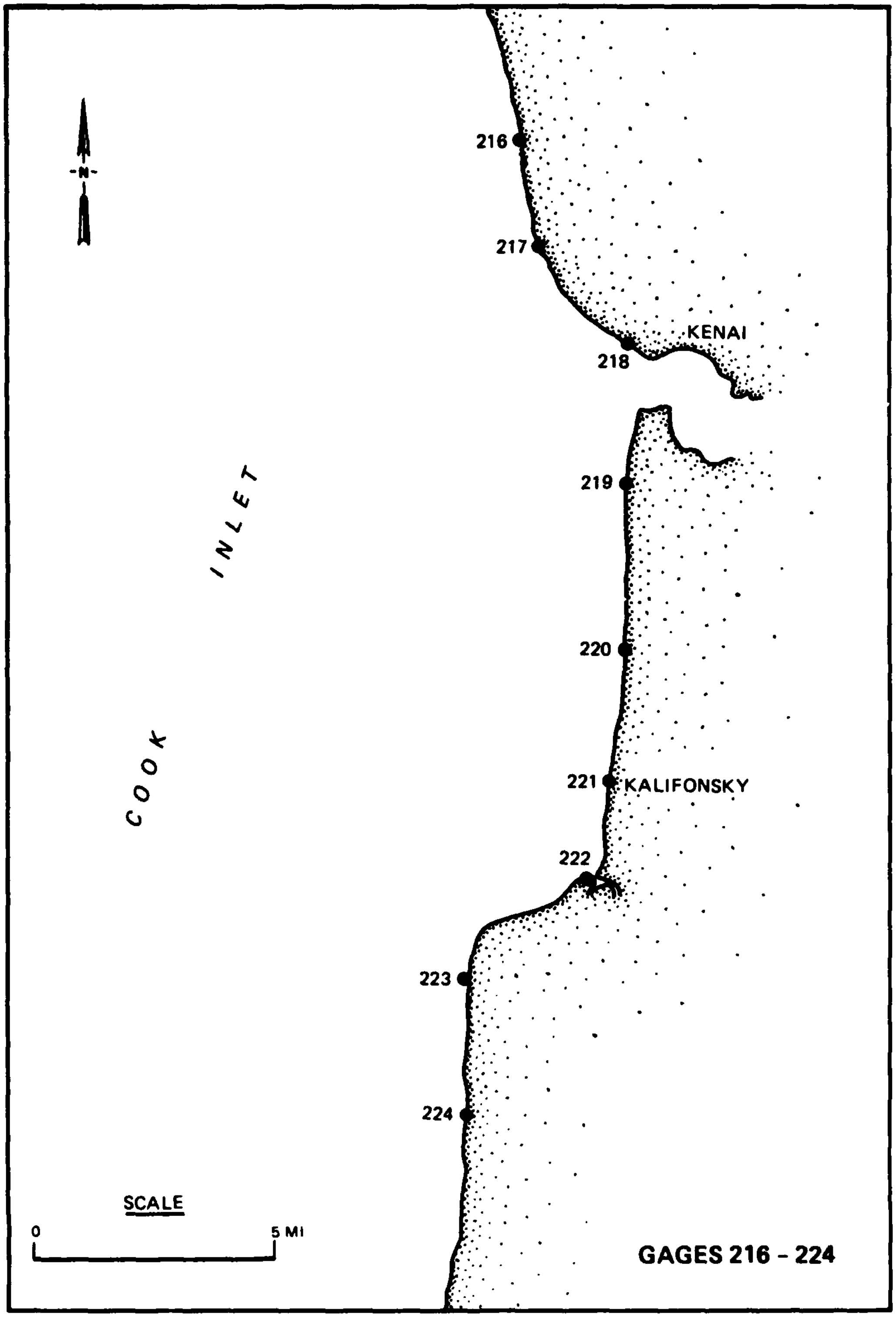

N
216
217
KENAI
218
219
220
221
KALIFONSKY
222
223
224
COOK INLET
SCALE
0
5 MI
GAGES 216 - 224

PLATE 17

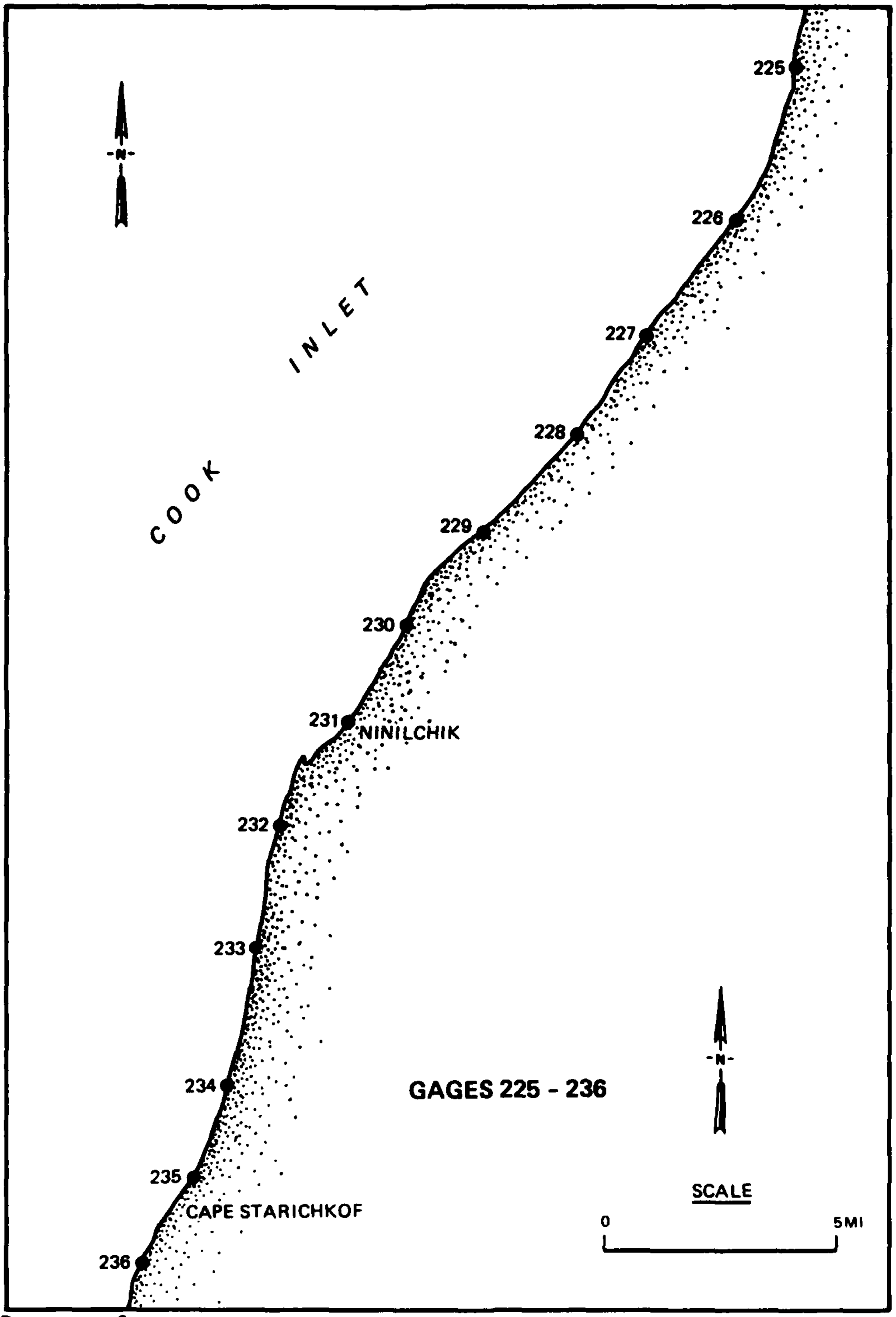

COOK INLET
225
226
227
228
229
230
231
NINILCHIK
232
233
234
235
CAPE STARICHKOF
236
GAGES 225 - 236
N
SCALE
0
5MI

PLATE 18

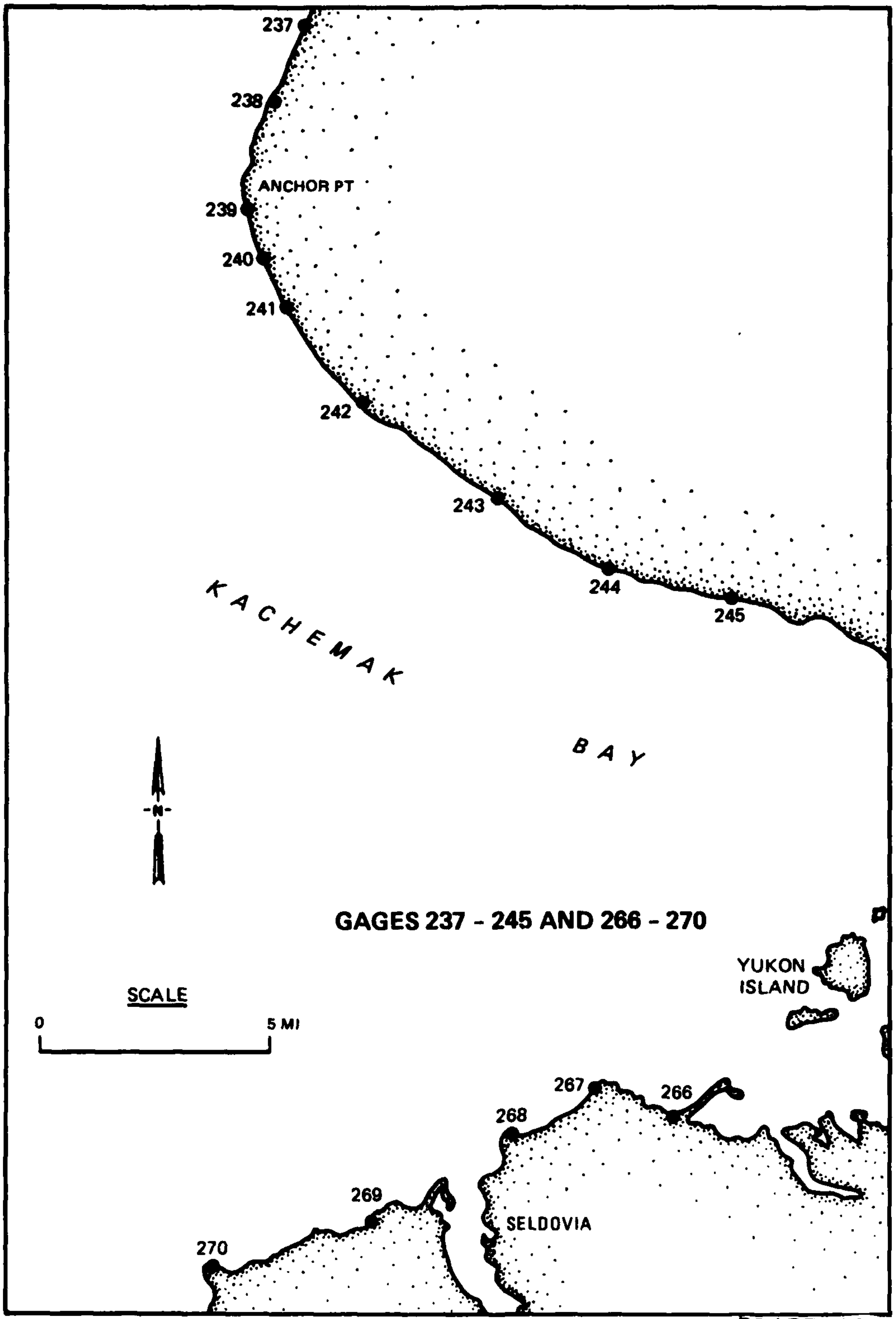
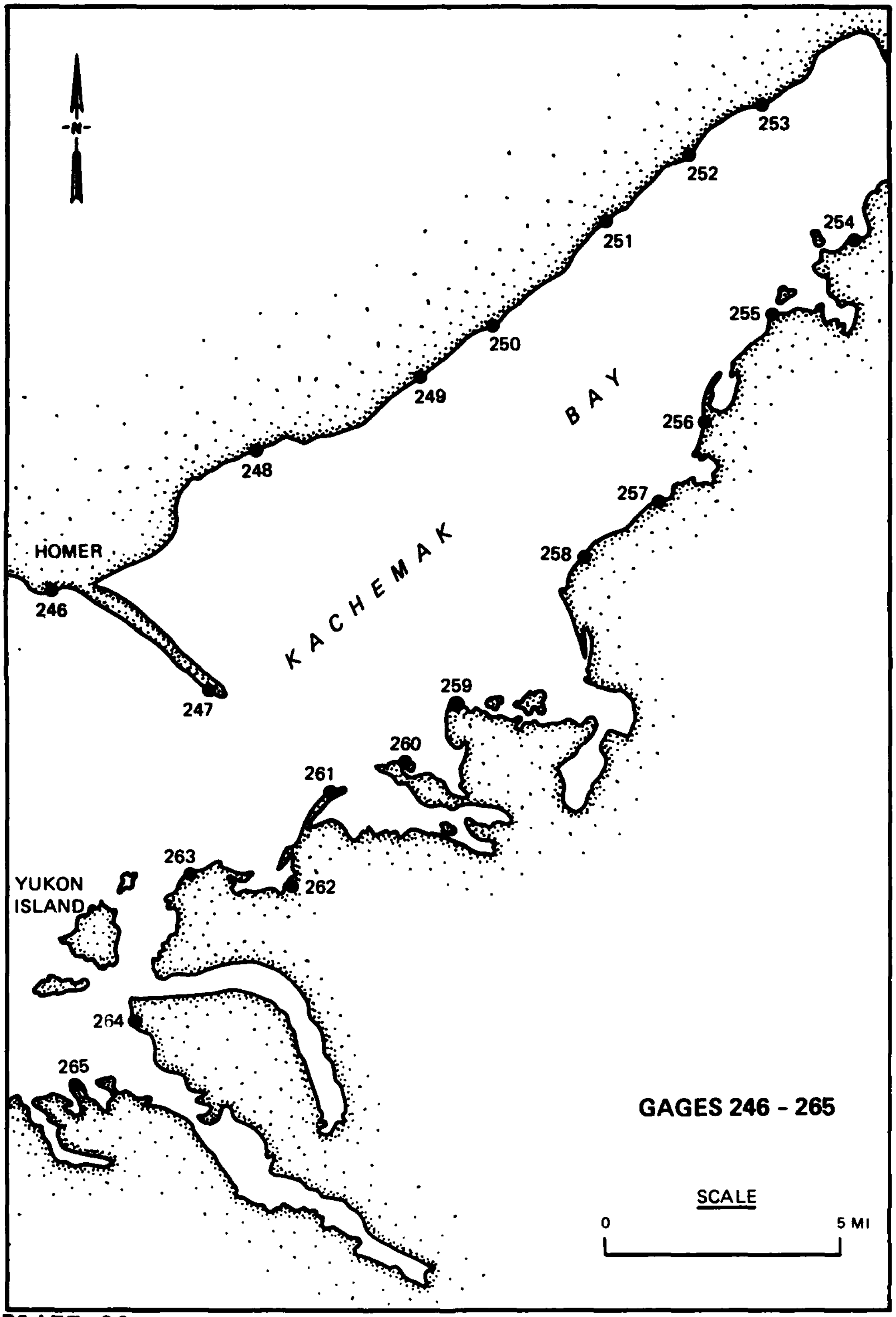

237
238
ANCHOR PT
239
240
241
242
243
244
245
KACHEMAK
BAY
N
GAGES 237 - 245 AND 266 - 270
SCALE
0
5 MI
YUKON ISLAND
267
266
268
269
270
SELDOVIA

PLATE 19



N
HOMER
246
247
248
249
250
251
252
253
254
255
256
257
258
259
260
261
262
263
264
265
KACHEMAK BAY
YUKON ISLAND
GAGES 246 - 265
SCALE
0
5 MI

PLATE 20

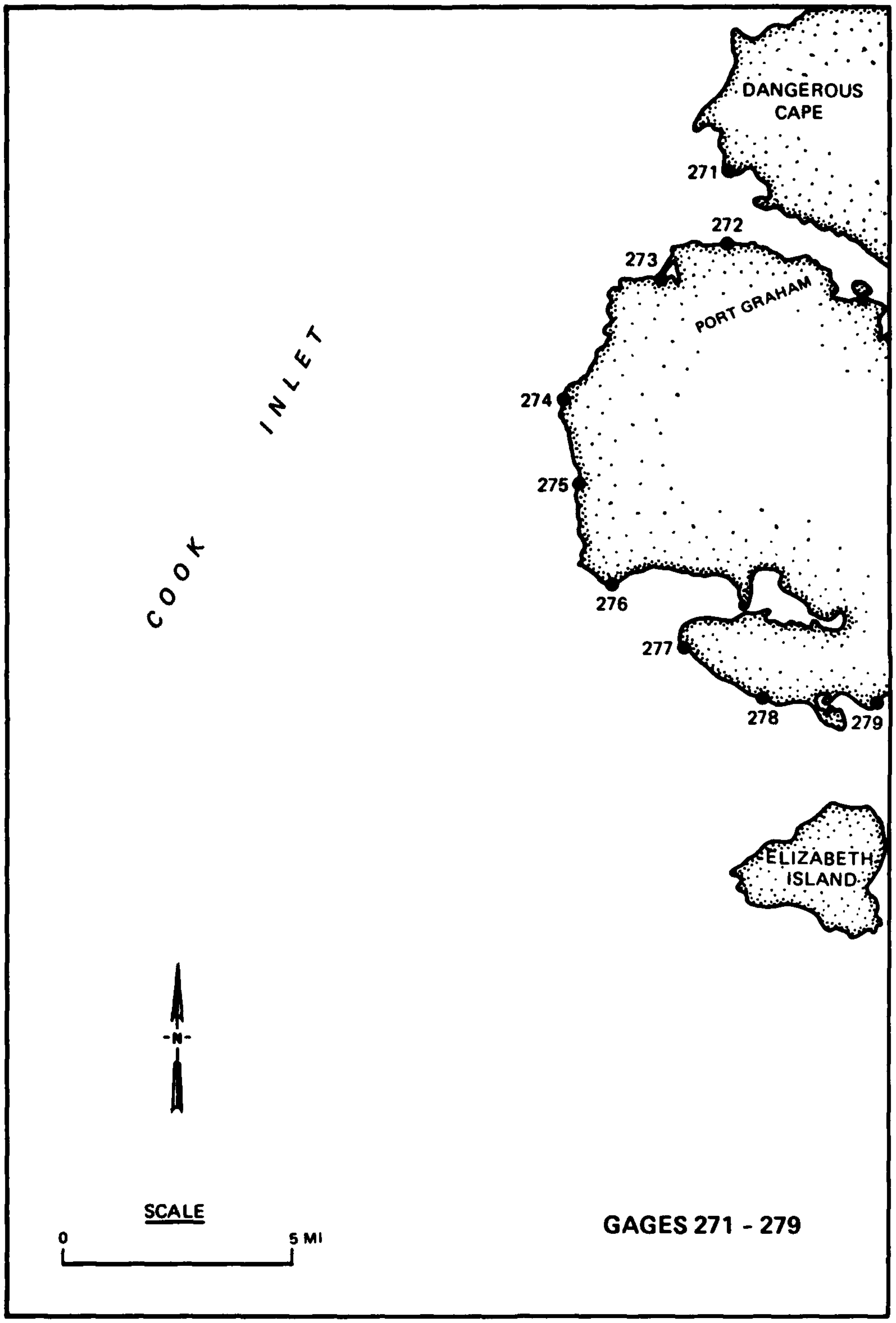

DANGEROUS CAPE
271
272
273
PORT GRAHAM
274
275
276
277
278
279
COOK INLET
ELIZABETH ISLAND
N
SCALE
0
5 MI
GAGES 271 - 279

PLATE 21

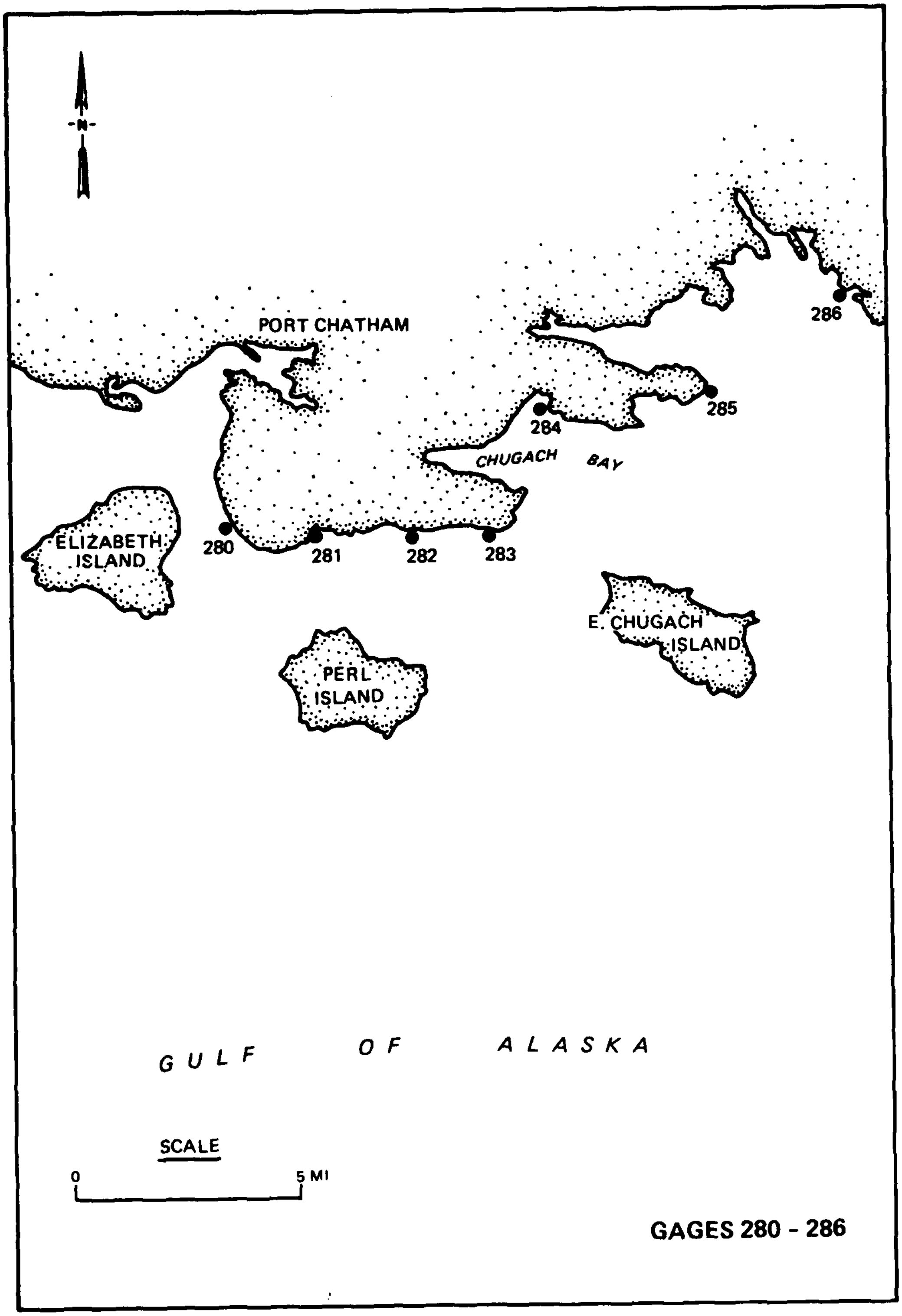

N
PORT CHATHAM
286
285
284
CHUGACH BAY
ELIZABETH ISLAND
280
281
282
283
E. CHUGACH ISLAND
PERL ISLAND
GULF OF ALASKA
SCALE
0
5 MI
GAGES 280 - 286

PLATE 22

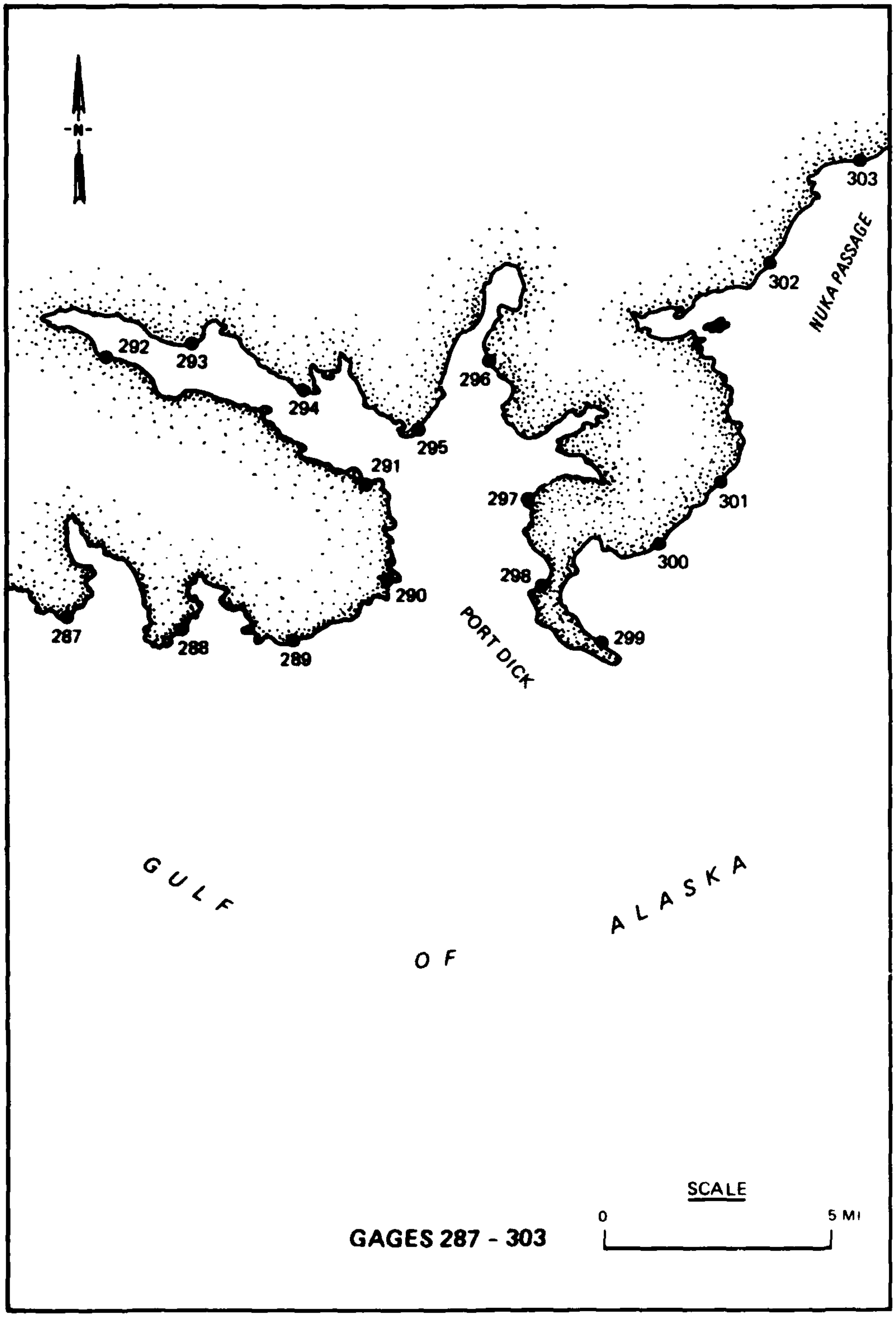
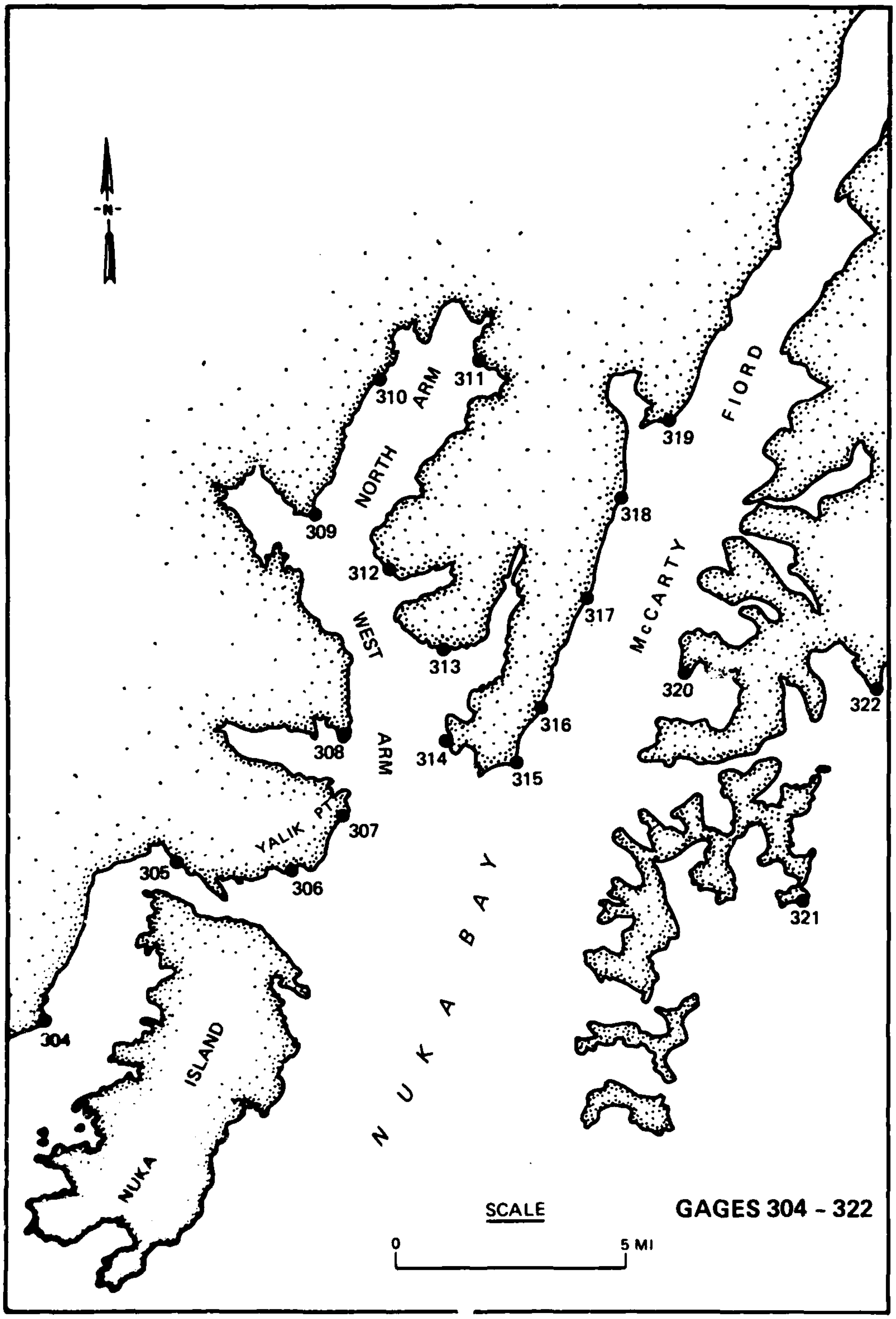

N
287
288
289
290
291
292
293
294
295
296
297
298
299
300
301
302
303
NUKA PASSAGE
PORT DICK
GULF OF ALASKA
SCALE
0
5 MI
GAGES 287 - 303

PLATE 23


N
310
311
NORTH ARM
319
FIORD
309
318
312
McCARTY
WEST
317
313
320
322
ARM
316
308
314
315
YALIK PT.
307
305
306
321
NUKA BAY
304
NUKA ISLAND
SCALE
0
5 MI
GAGES 304 - 322

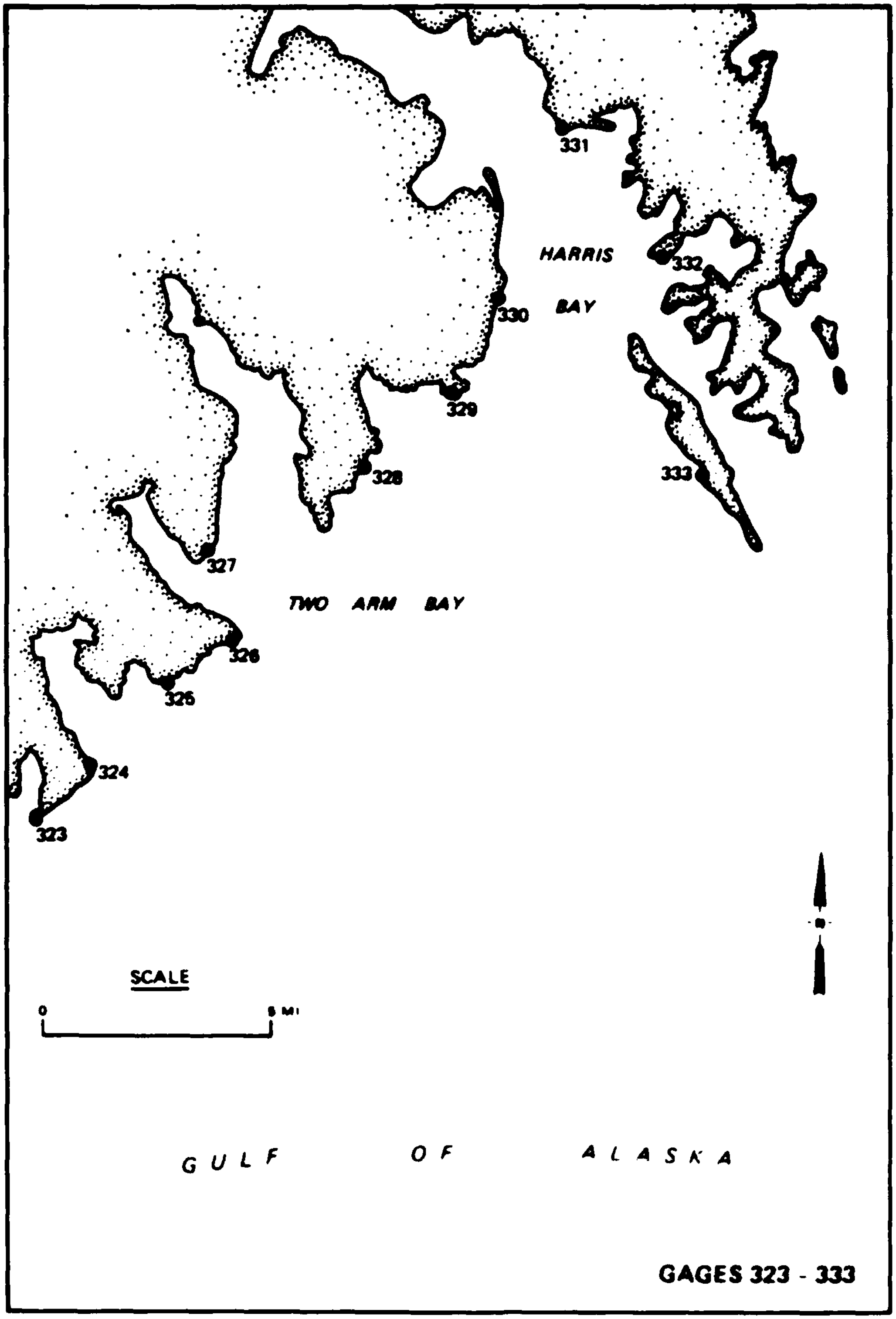

331
HARRIS
BAY
332
330
329
328
333
327
TWO ARM BAY
326
325
324
323
SCALE
0
5 MI
GULF OF ALASKA
GAGES 323 - 333

PLATE 75

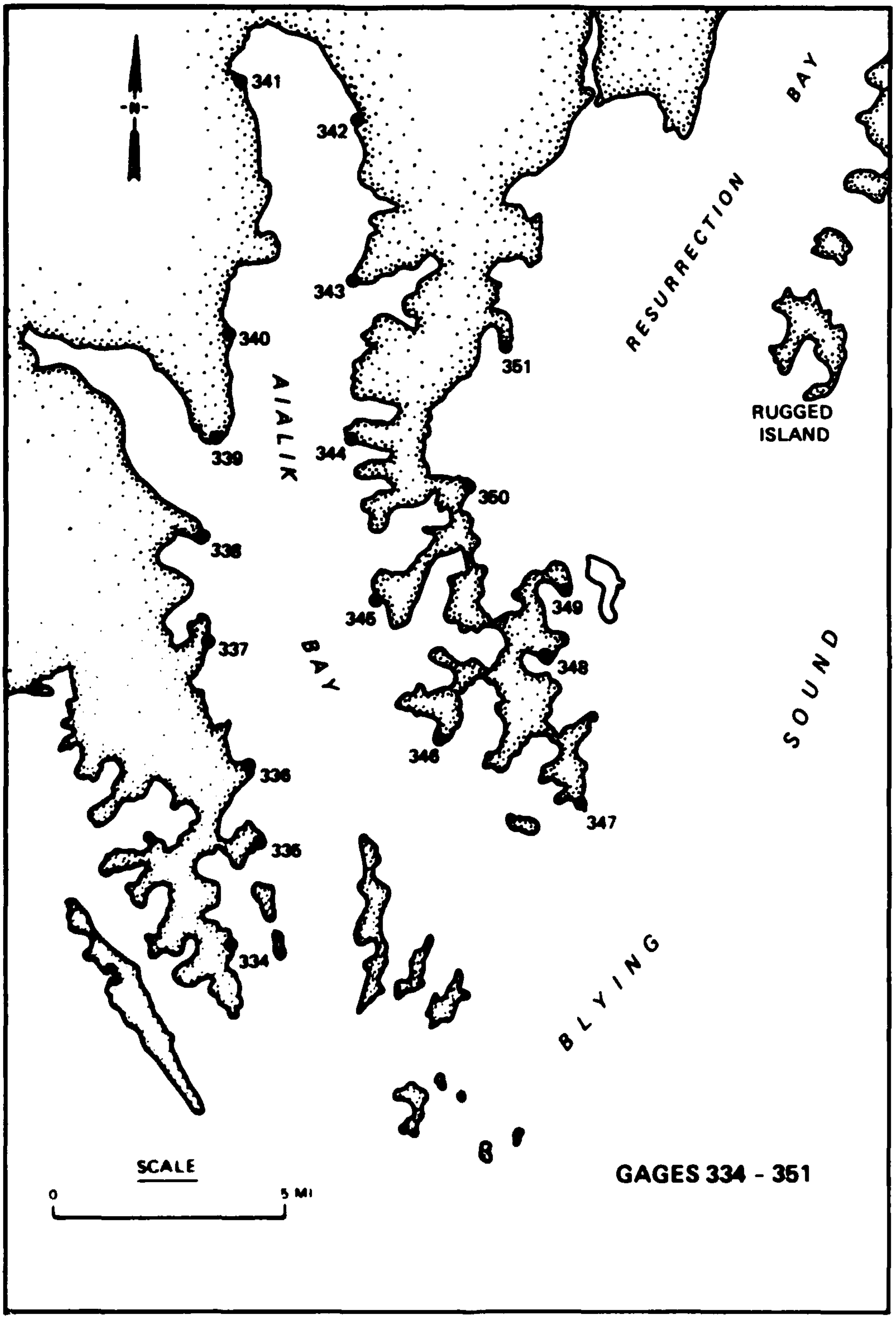

N
341
342
343
340
339
351
RESURRECTION
BAY
AIALIK
BAY
344
350
RUGGED
ISLAND
338
337
345
349
348
346
336
335
347
334
SOUND
BLYING
SCALE
0
5 MI
GAGES 334 - 351

PLATE 26

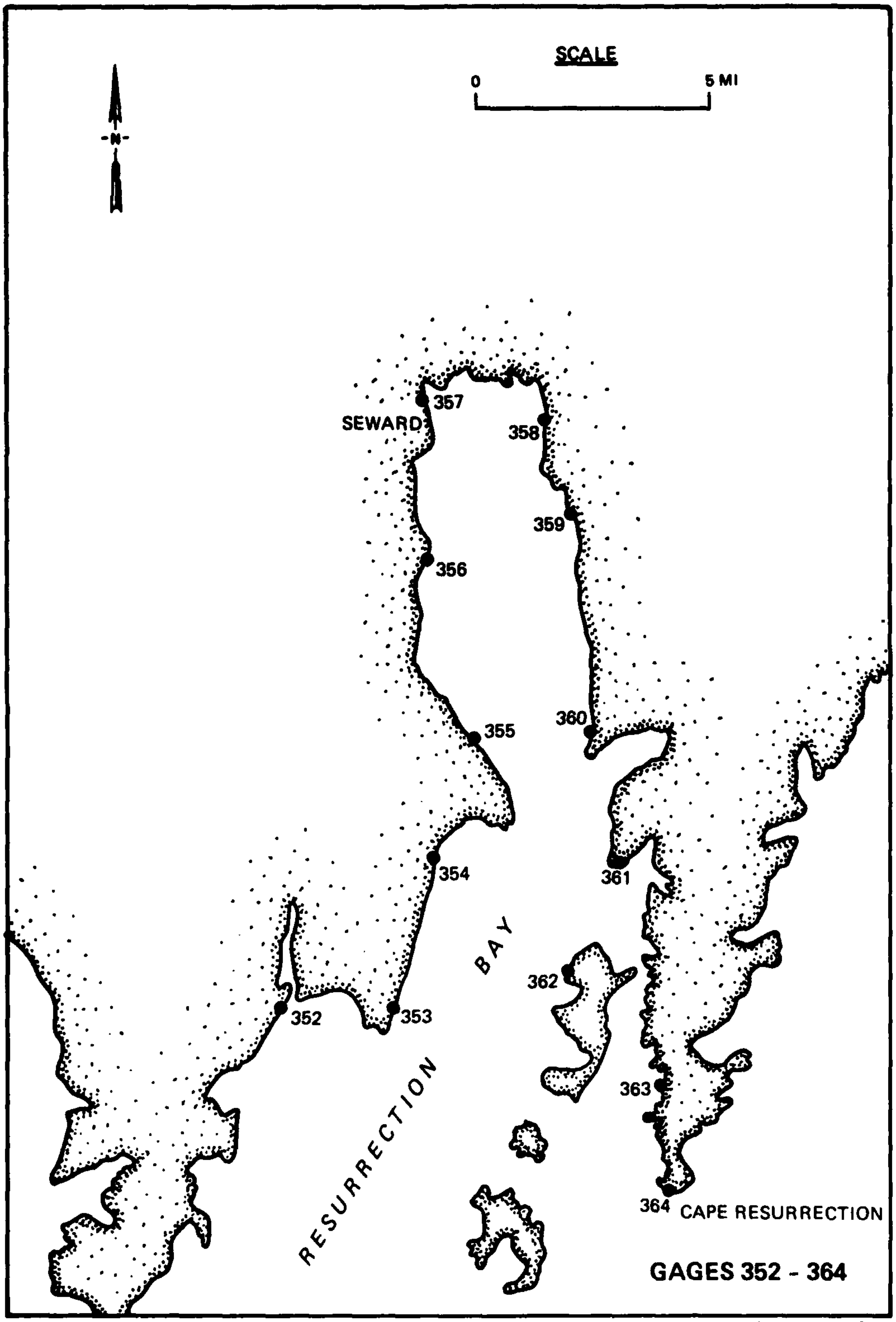

SCALE
0
5 MI
N
SEWARD
357
358
359
356
355
360
354
361
BAY
362
352
353
RESURRECTION
363
364
CAPE RESURRECTION
GAGES 352 - 364

PLATE 27

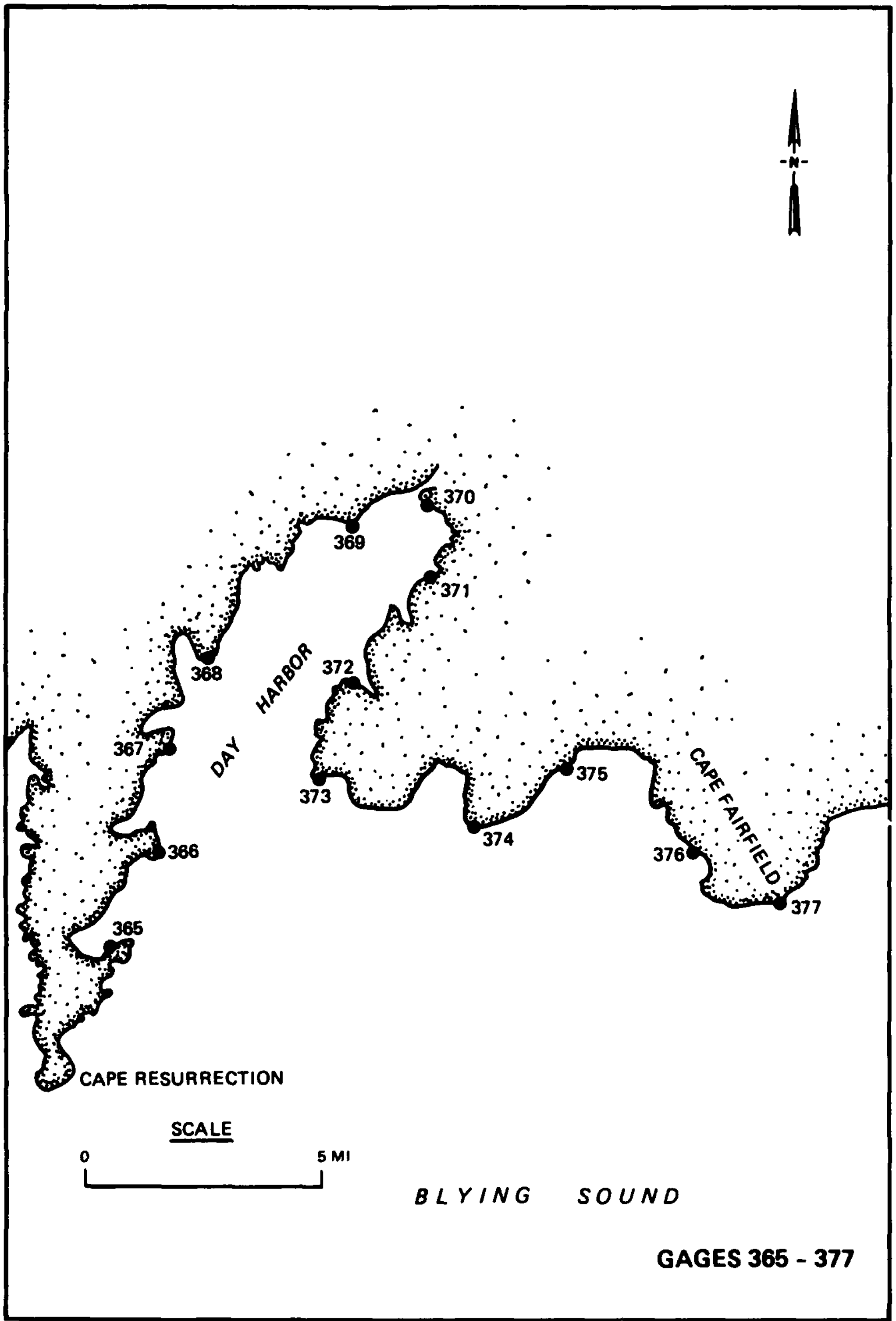

370
369
371
368
372
DAY HARBOR
367
373
375
374
CAPE FAIRFIELD
366
376
377
365
CAPE RESURRECTION
SCALE
0
5 MI
BLYING SOUND
GAGES 365 - 377

PLATE 28

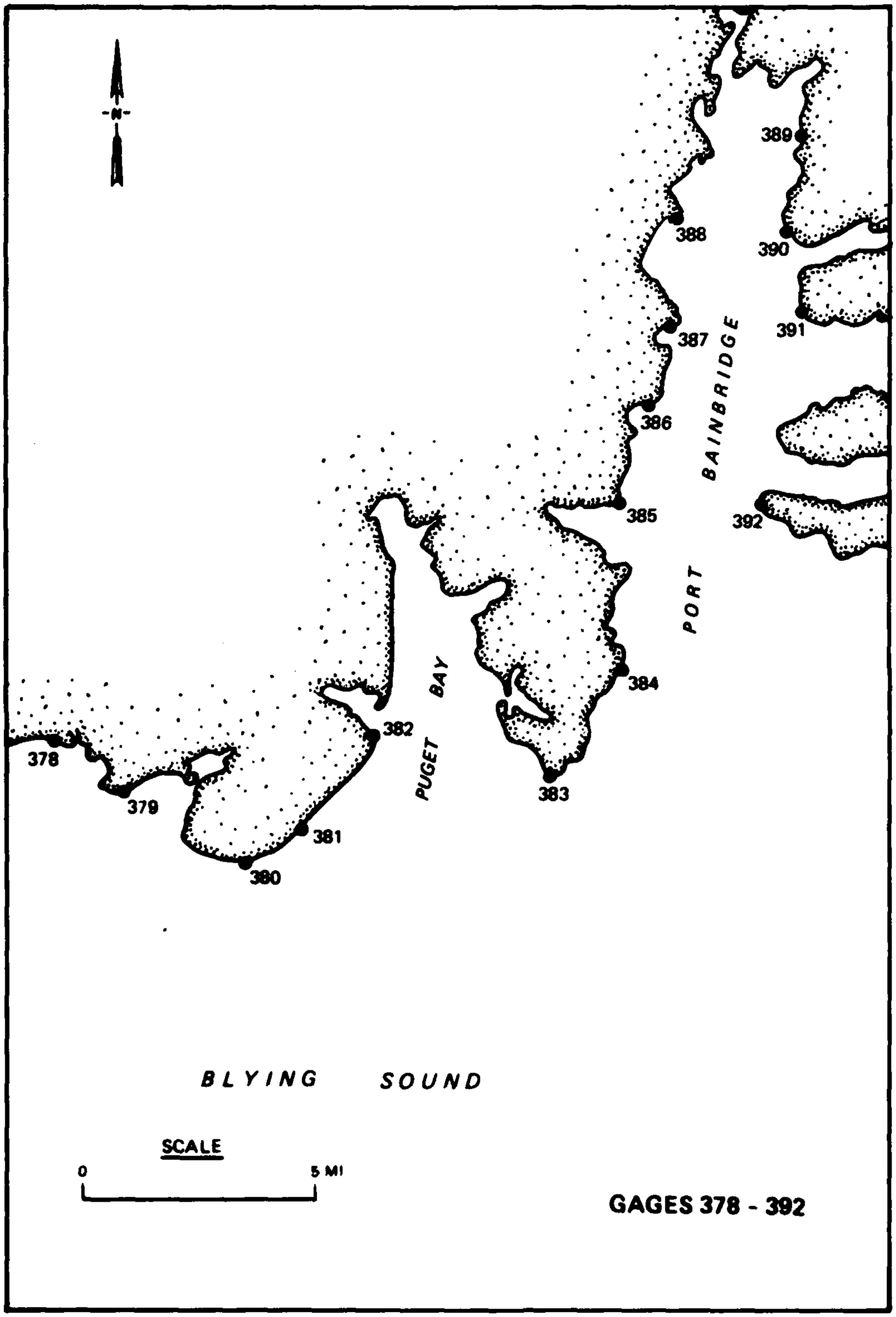

N
378
379
380
381
382
383
384
385
386
387
388
389
390
391
392
PUGET BAY
PORT BAINBRIDGE
BLYING SOUND
SCALE
0
5 MI
GAGES 378 - 392

PLATE 29

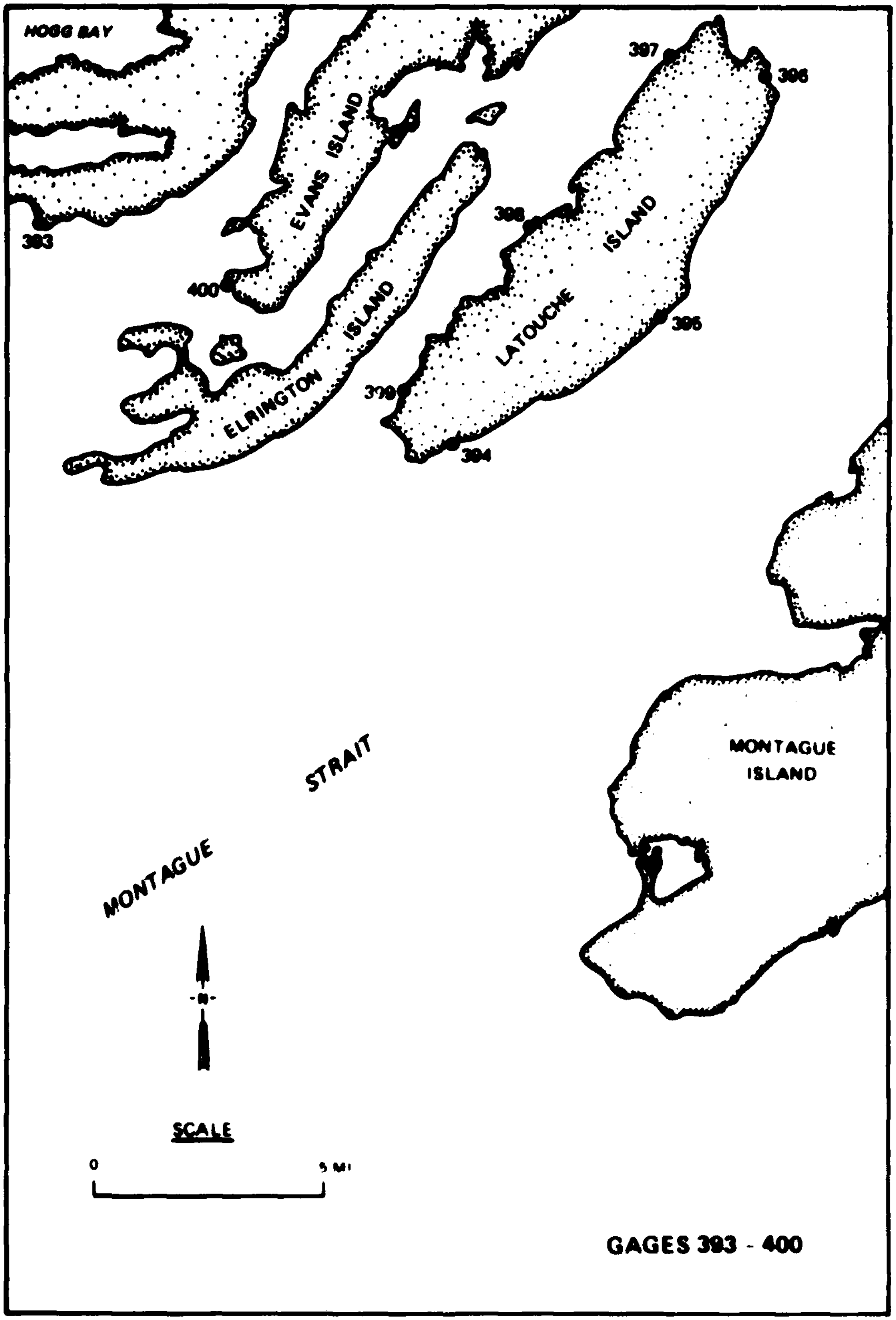

HOGG BAY
EVANS ISLAND
ELRINGTON ISLAND
LATOUCHE ISLAND
MONTAGUE ISLAND
MONTAGUE STRAIT
397
398
396
393
400
395
399
394
N
SCALE
0
5 MI
GAGES 393 - 400

PLATE 30

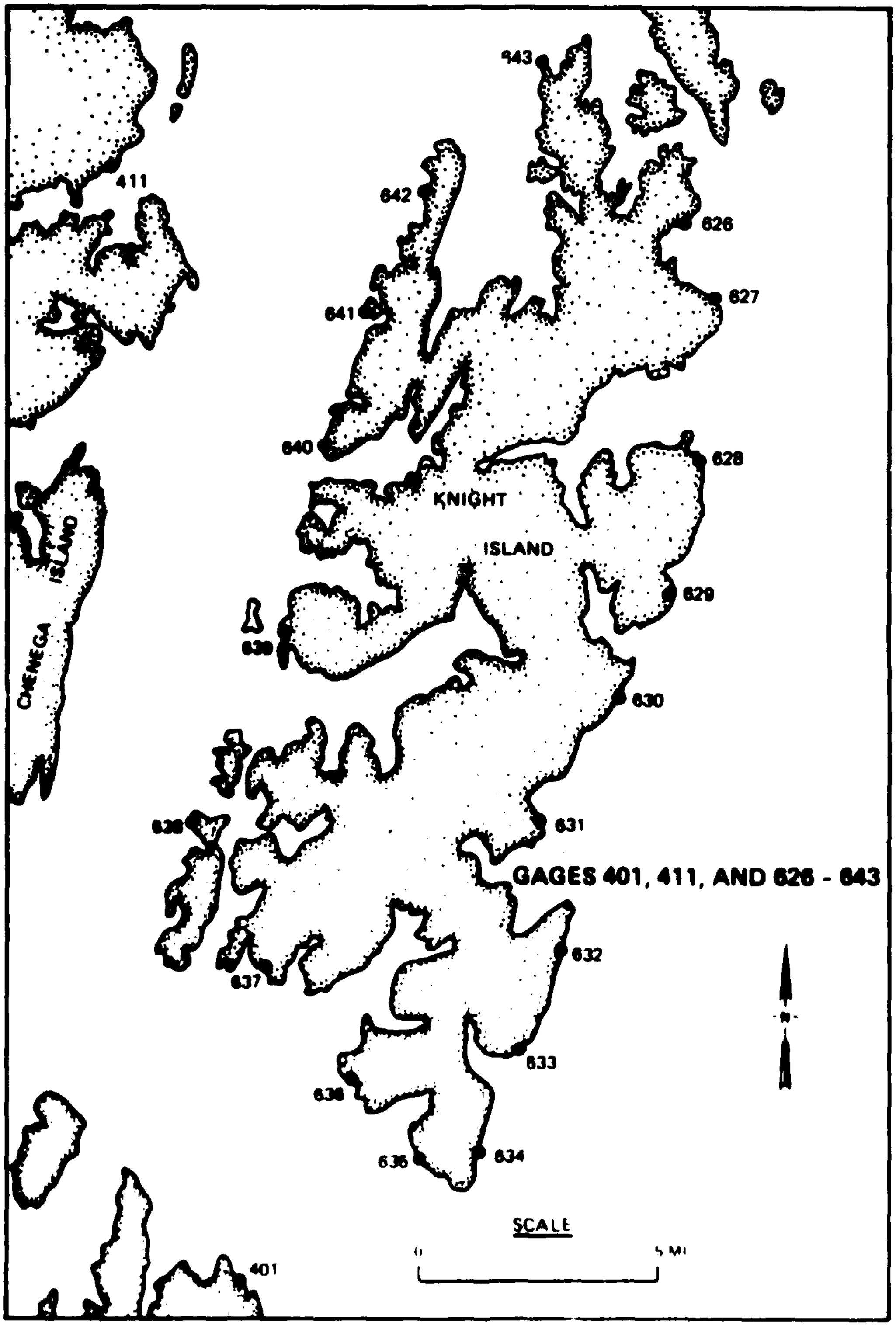

643
411
642
626
627
641
640
628
KNIGHT
ISLAND
CHENEGA ISLAND
629
639
630
631
638
GAGES 401, 411, AND 626 - 643
632
637
633
N
636
635
634
SCALE
0
5 MI
401

PLATE 31

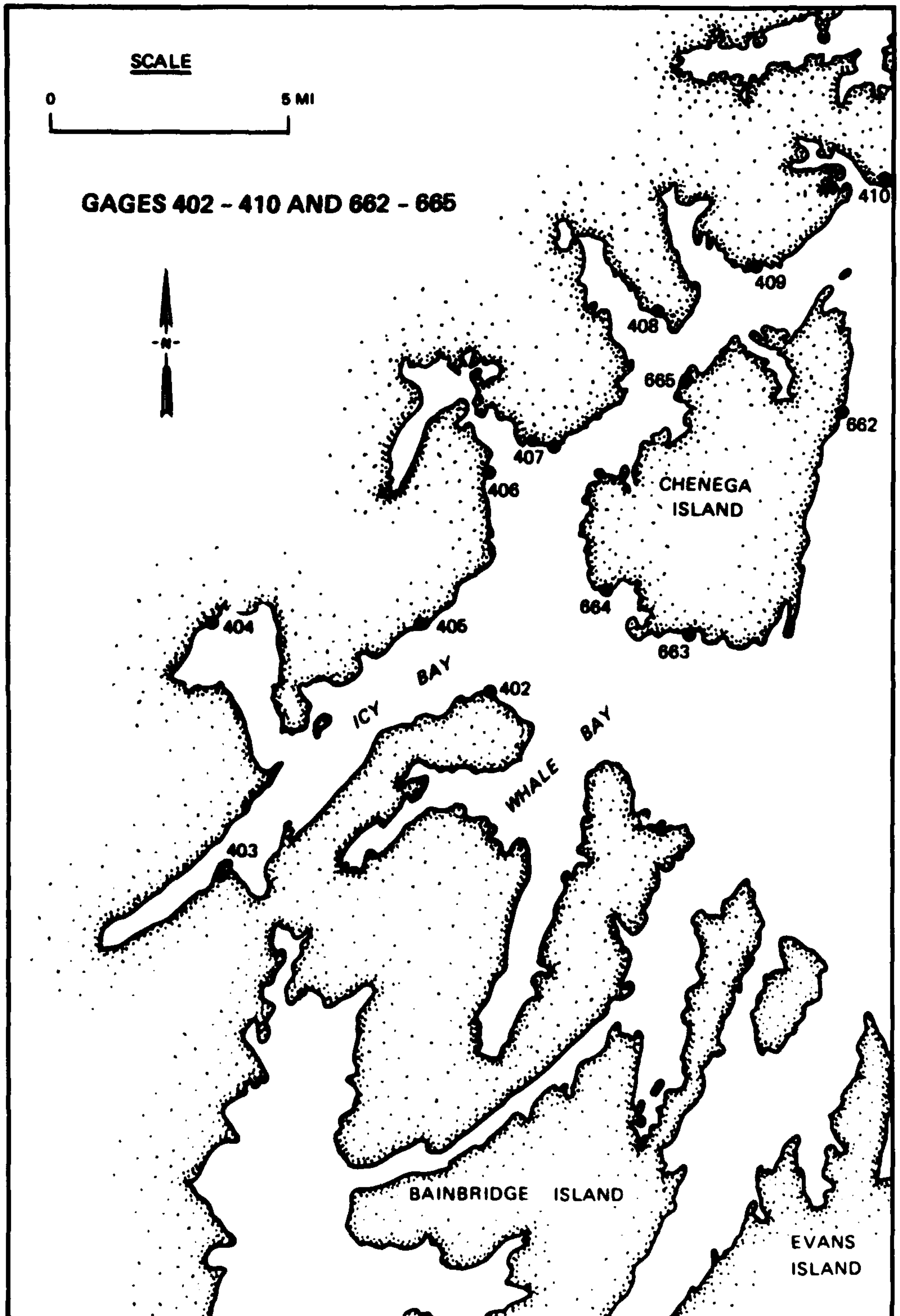

SCALE
0
5 MI
GAGES 402 - 410 AND 662 - 665
-N-
410
409
408
665
662
407
406
CHENEGA
ISLAND
664
404
405
663
BAY
402
ICY
BAY
WHALE
403
BAINBRIDGE ISLAND
EVANS
ISLAND

PLATE 32

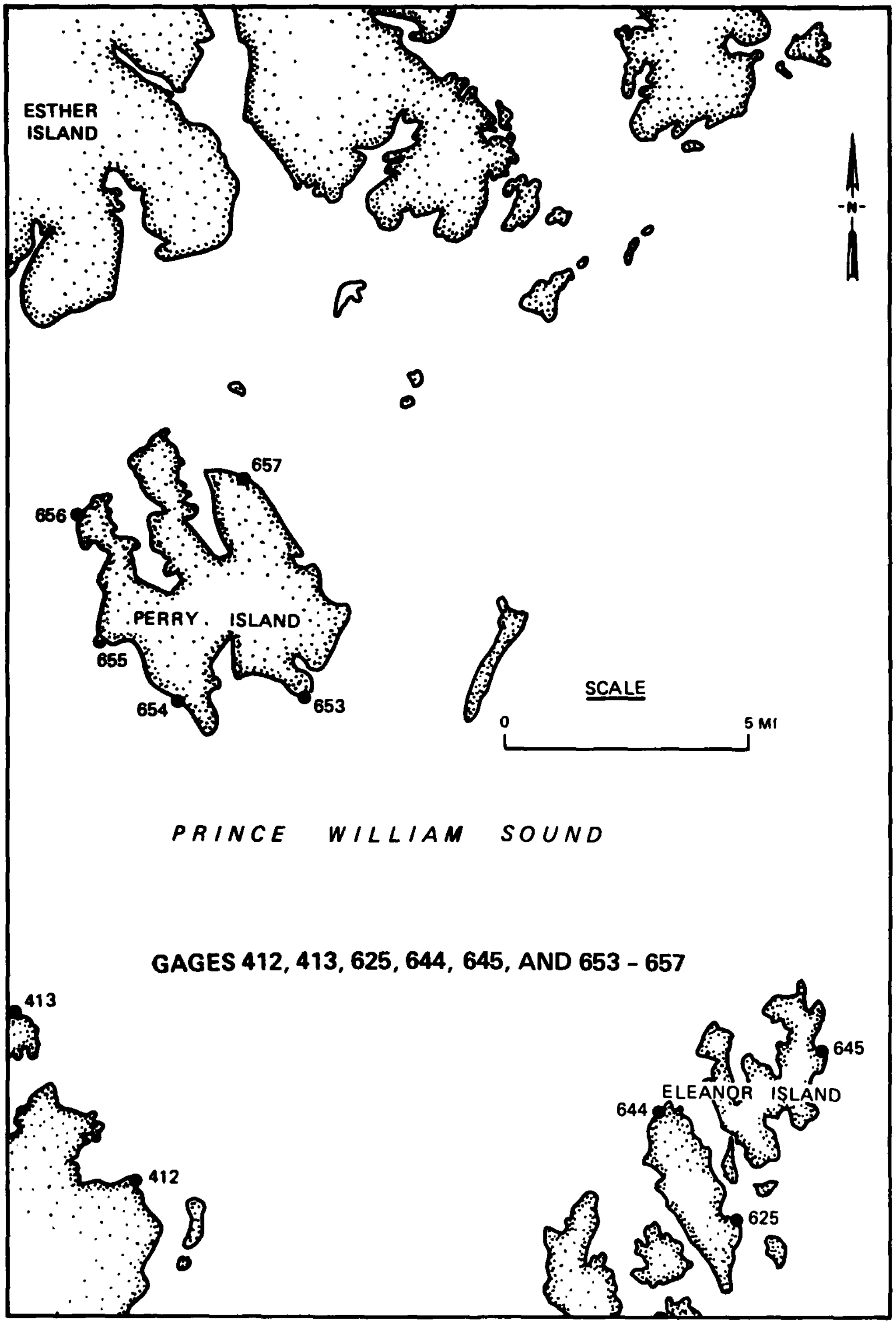

ESTHER
ISLAND
657
656
PERRY ISLAND
655
654
653
SCALE
0
5 MI
N
PRINCE WILLIAM SOUND
GAGES 412, 413, 625, 644, 645, AND 653 - 657
413
412
645
ELEANOR ISLAND
644
625

PLATE 33

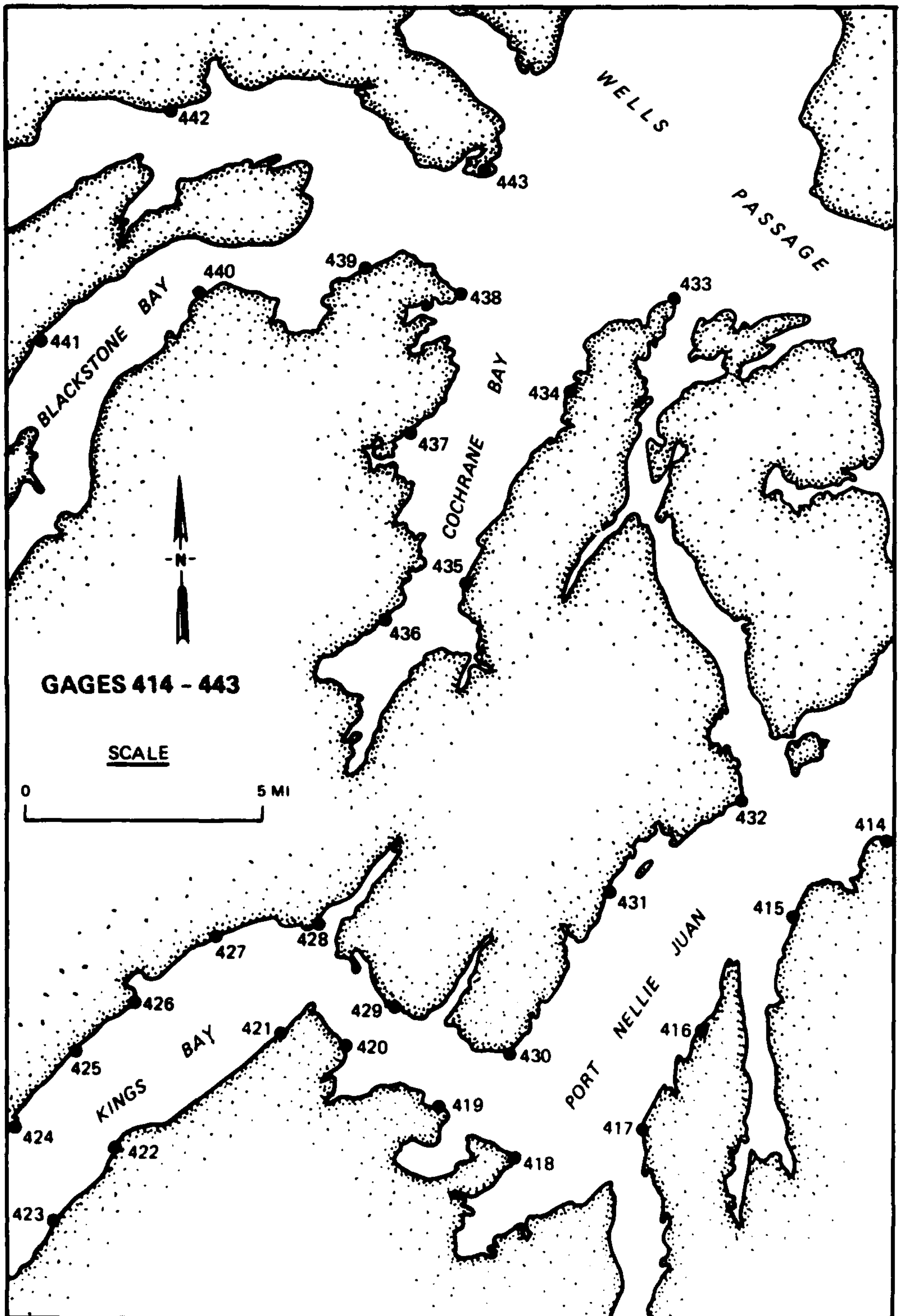

WELLS PASSAGE
BLACKSTONE BAY
COCHRANE BAY
KINGS BAY
PORT NELLIE JUAN
GAGES 414 - 443
SCALE
0
5 MI
N
414
415
416
417
418
419
420
421
422
423
424
425
426
427
428
429
430
431
432
433
434
435
436
437
438
439
440
441
442
443

PLATE 34

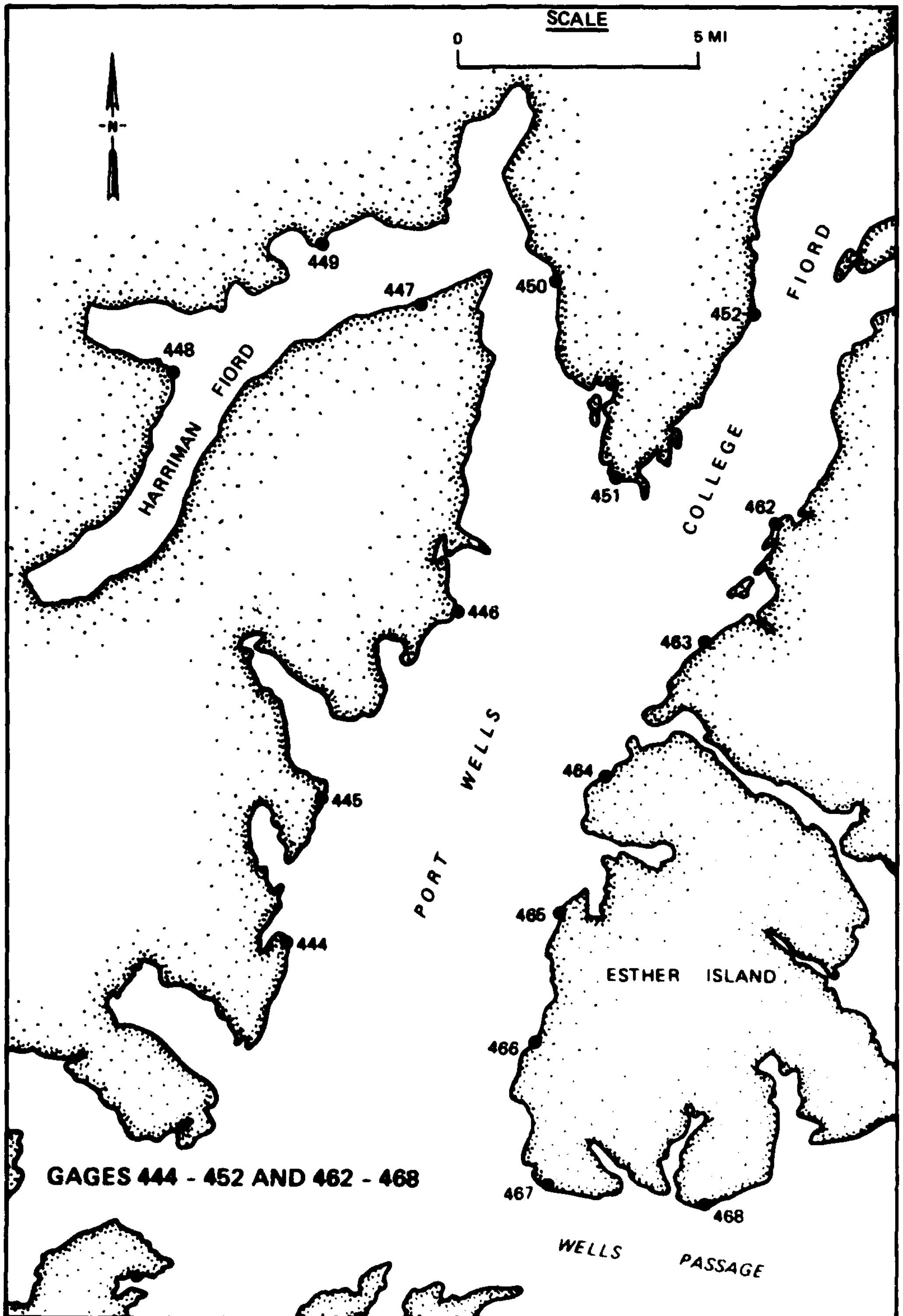

SCALE
0
5 MI
N
449
447
450
452
448
HARRIMAN FIORD
COLLEGE FIORD
451
462
446
463
PORT WELLS
464
445
465
ESTHER ISLAND
444
466
GAGES 444 - 452 AND 462 - 468
467
468
WELLS PASSAGE

PLATE 35

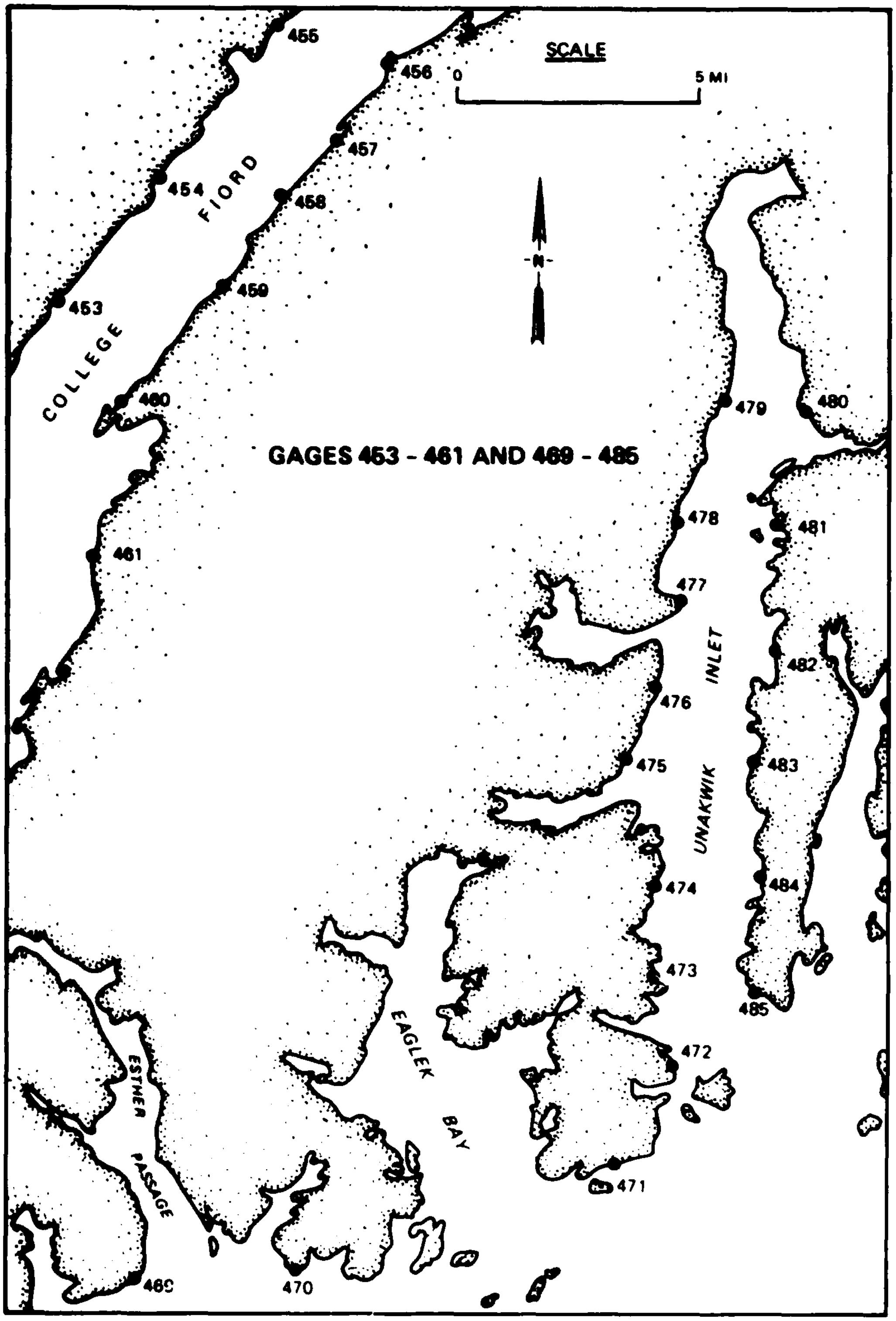
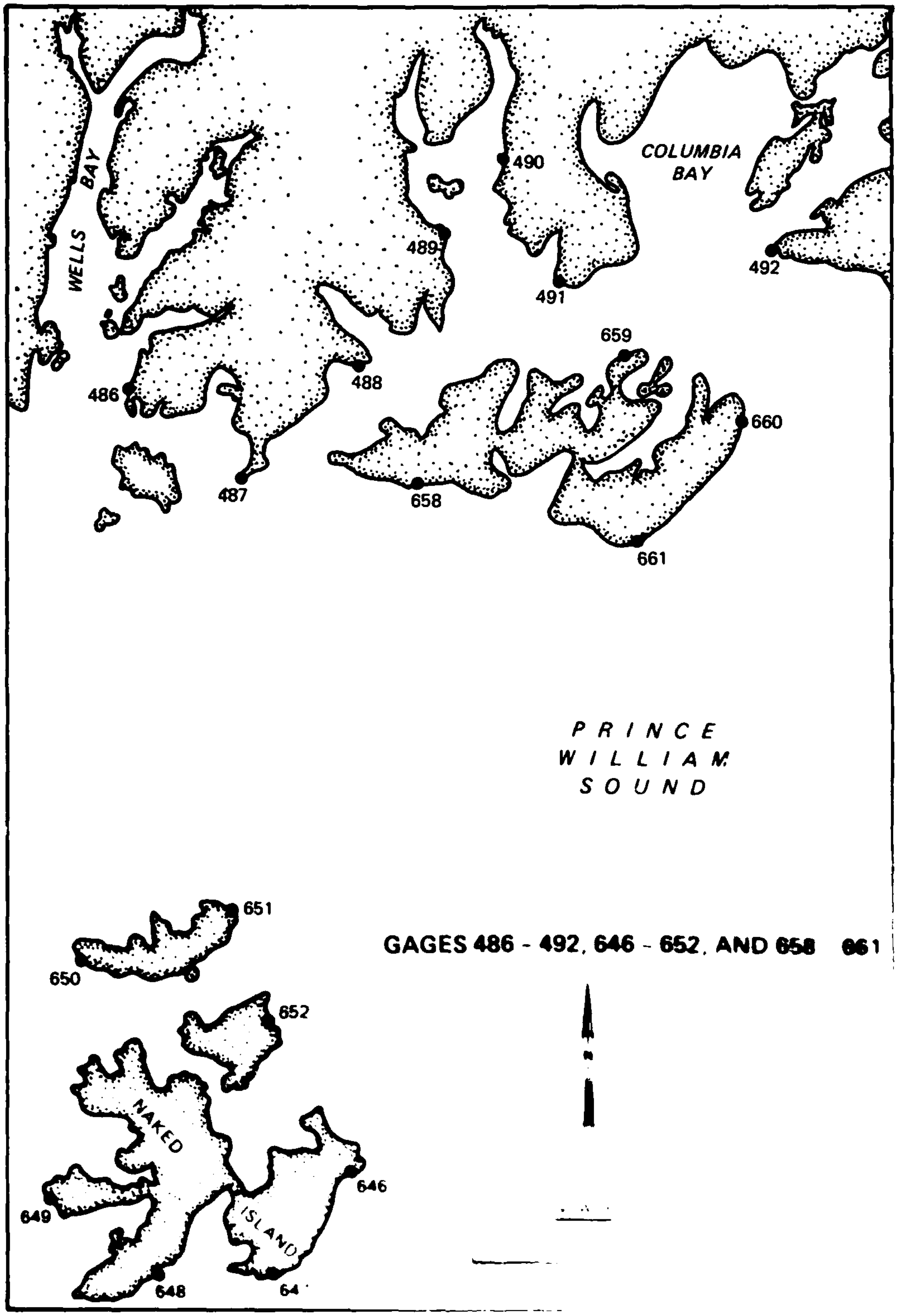

SCALE
0
5 MI
N
GAGES 453 - 461 AND 469 - 485
COLLEGE
FIORD
INLET
UNAKWIK
EAGLEK
BAY
ESTHER
PASSAGE
453
454
455
456
457
458
459
460
461
469
470
471
472
473
474
475
476
477
478
479
480
481
482
483
484
485

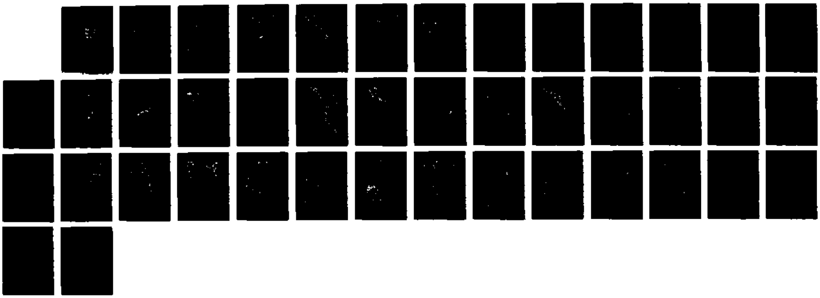
PLATE 36

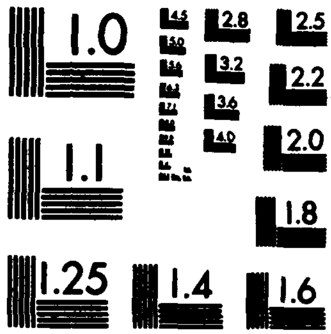


GAGES 486 - 492, 646 - 652, AND 658 661

AD-A181 775 TSUNAMI PREDICTIONS FOR THE COAST OF ALASKA KODIAK ISLAND TO KETCHIKAN(U) COASTAL ENGINEERING RESEARCH CENTER VICKSBURG MS P L CRAWFORD APR 87 CERC-TR-87-7 2/2

UNCLASSIFIED F/G 8/3 NL





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

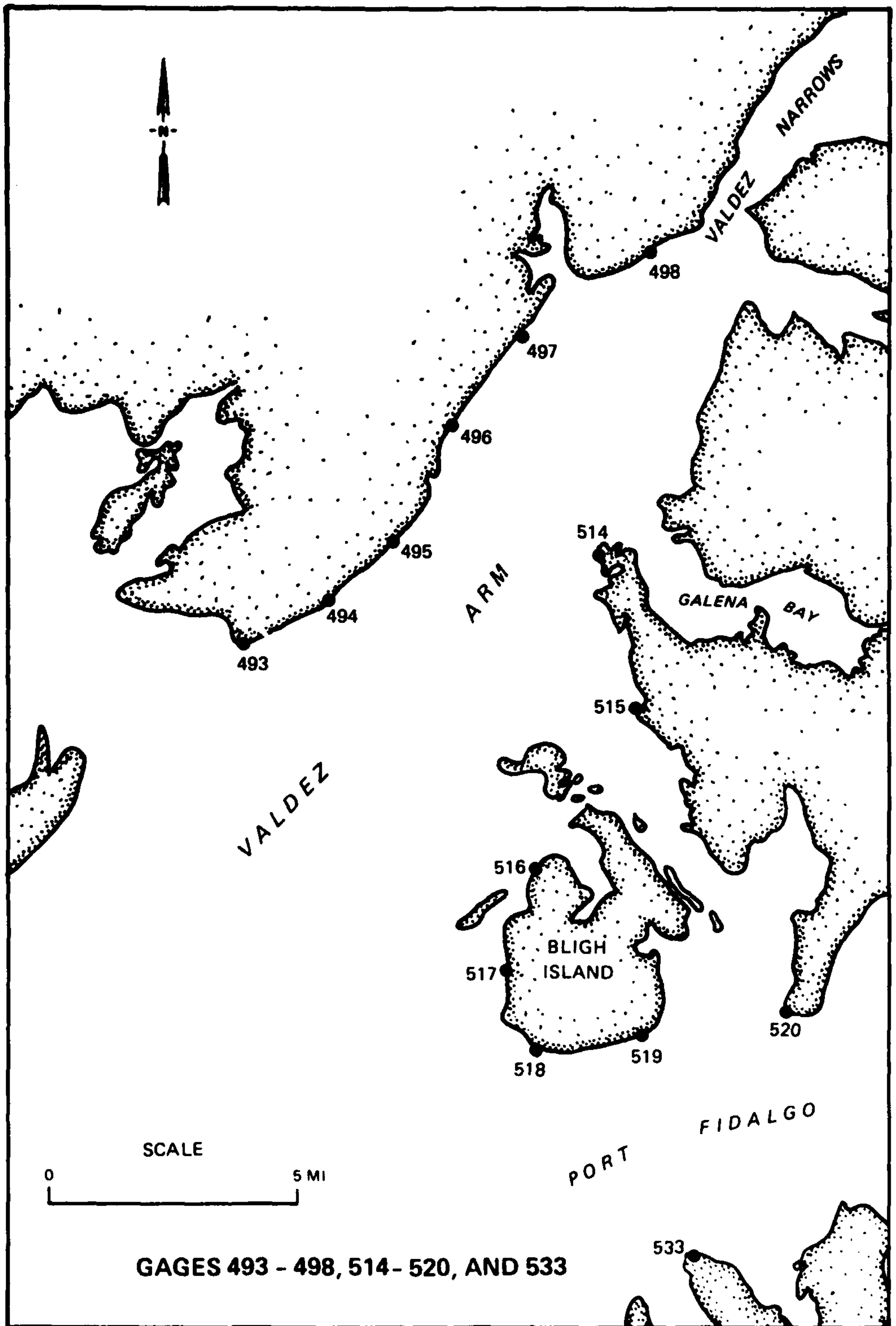

N
VALDEZ NARROWS
498
497
496
495
494
493
514
GALENA BAY
ARM
VALDEZ
515
516
517
BLIGH ISLAND
518
519
520
PORT FIDALGO
SCALE
0
5 MI
533
GAGES 493 - 498, 514- 520, AND 533

PLATE 38

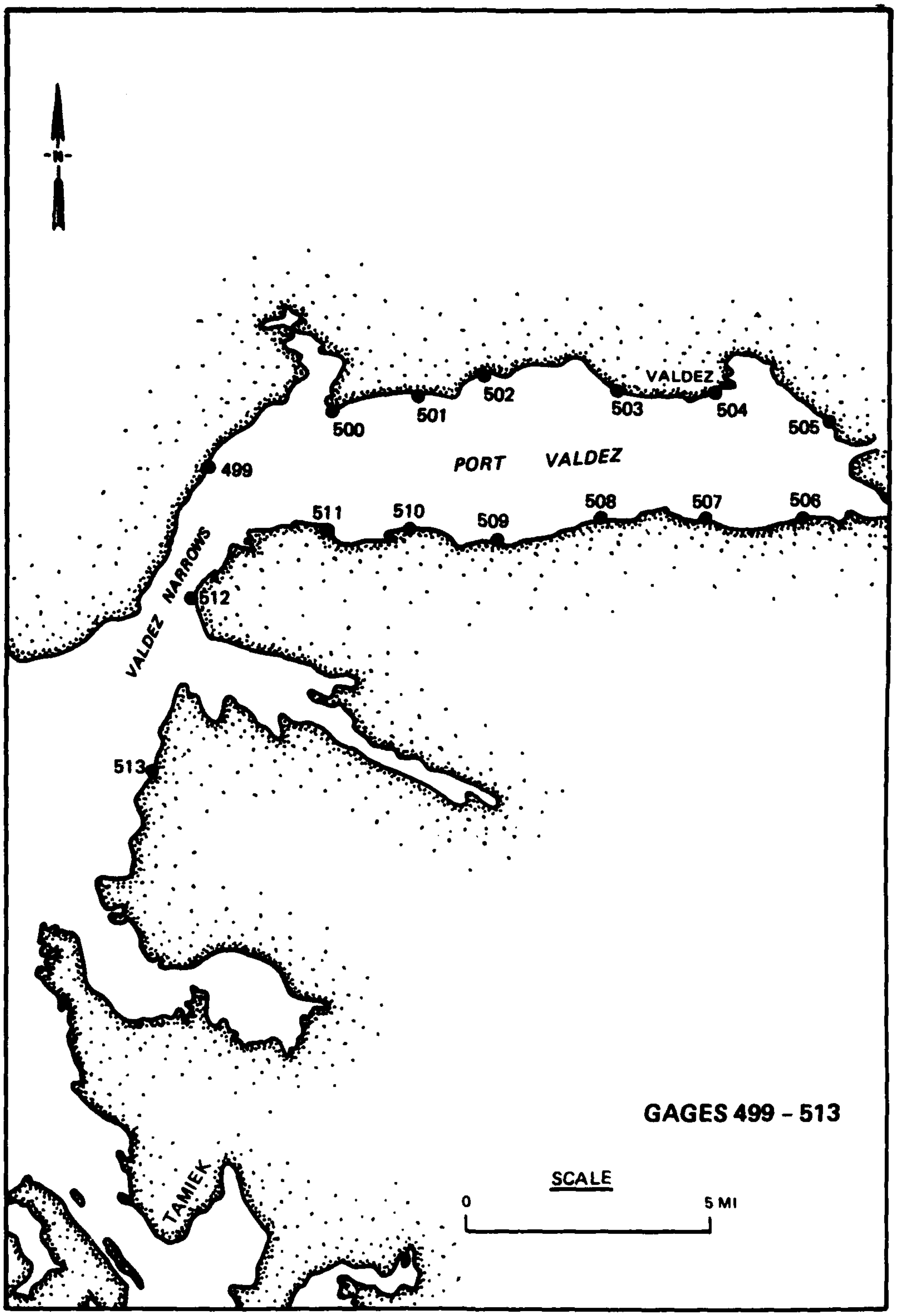
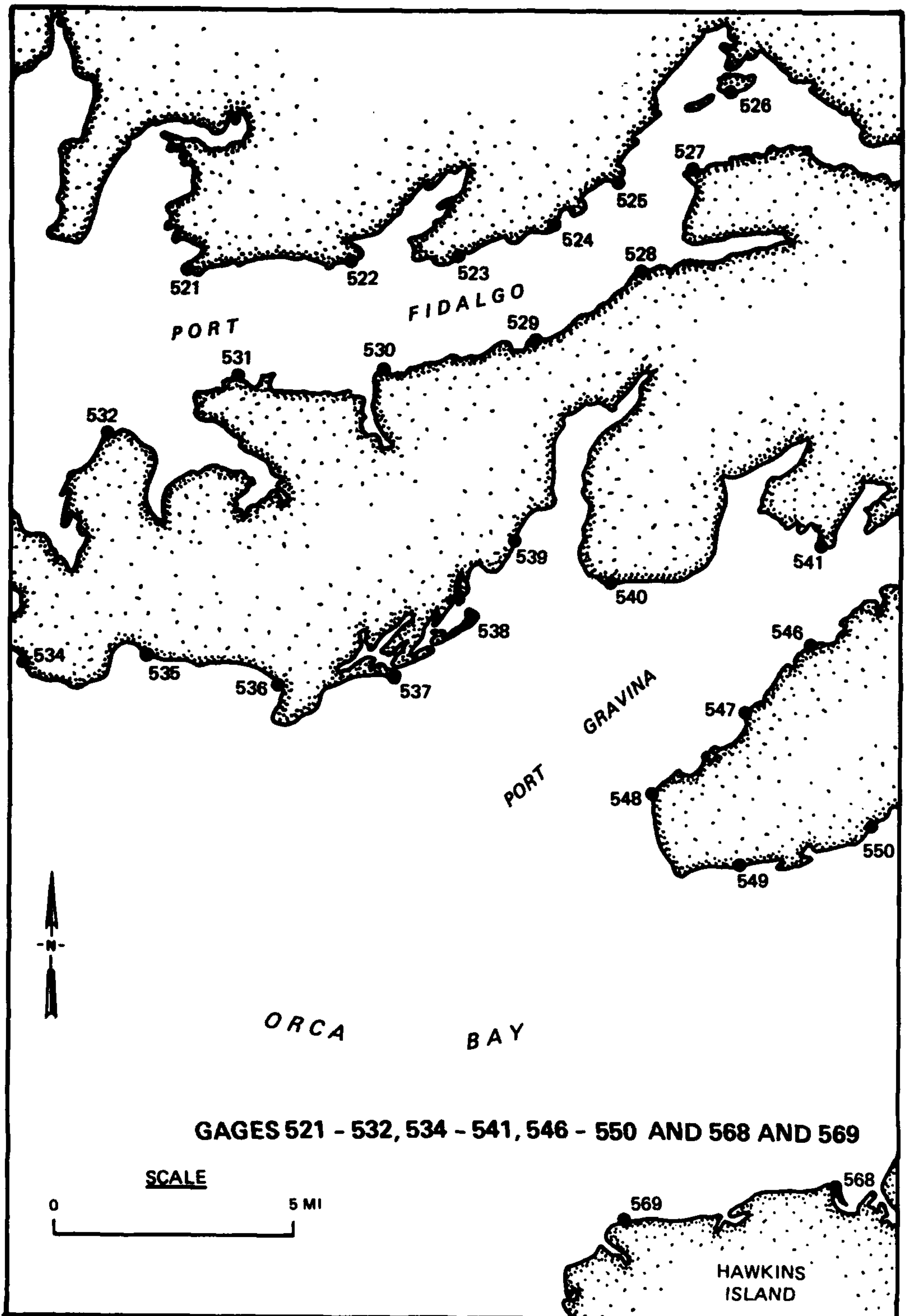

N
VALDEZ
500
501
502
503
504
505
499
PORT VALDEZ
511
510
509
508
507
506
VALDEZ NARROWS
512
513
TAMIEK
GAGES 499 - 513
SCALE
0
5 MI

PLATE 39



526
527
525
524
528
521
522
523
PORT
FIDALGO
529
530
531
532
539
540
541
538
546
534
535
536
537
GRAVINA
547
PORT
548
550
549
N
ORCA
BAY
GAGES 521 - 532, 534 - 541, 546 - 550 AND 568 AND 569
SCALE
0
5 MI
569
568
HAWKINS
ISLAND

PLATE 40

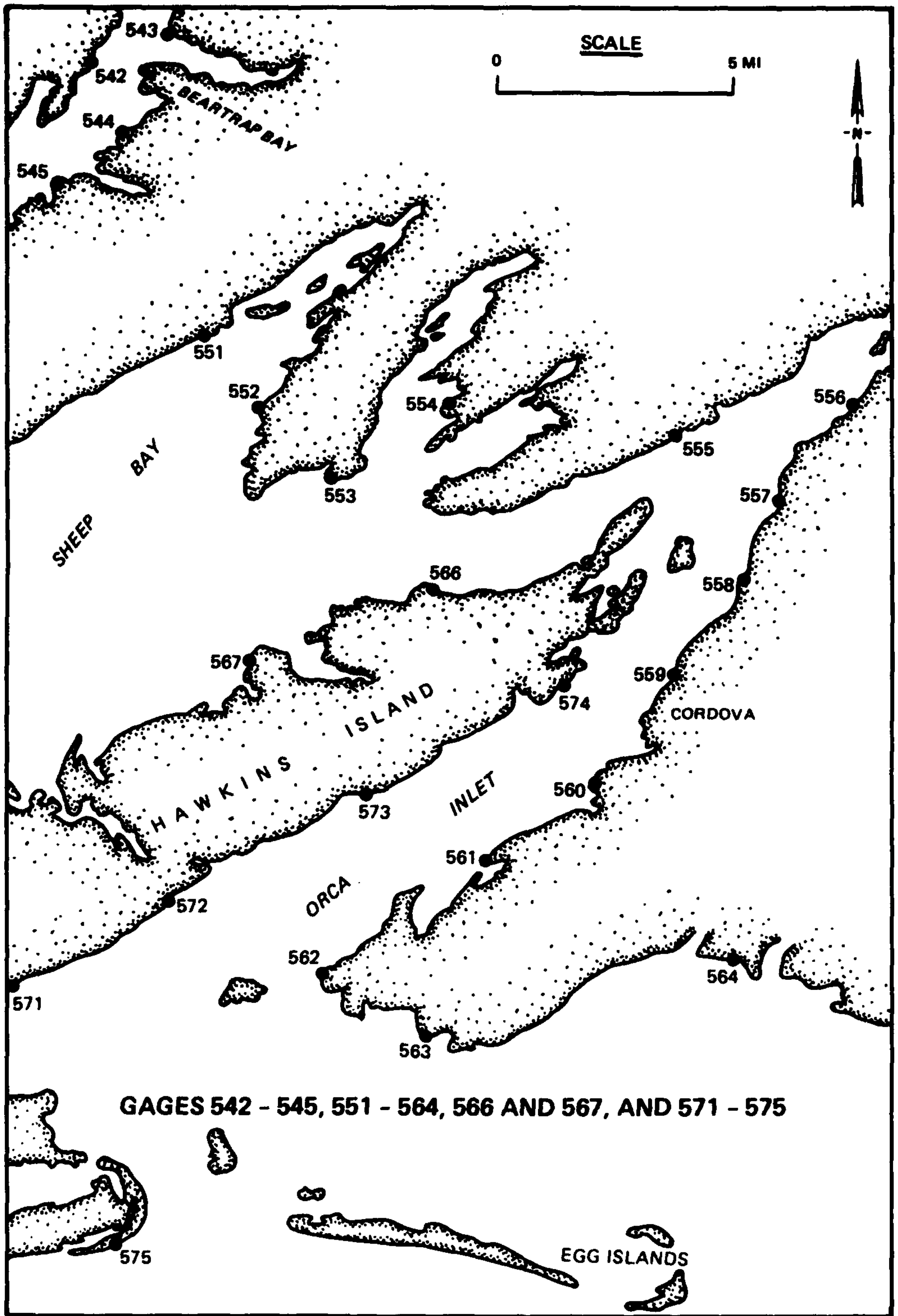
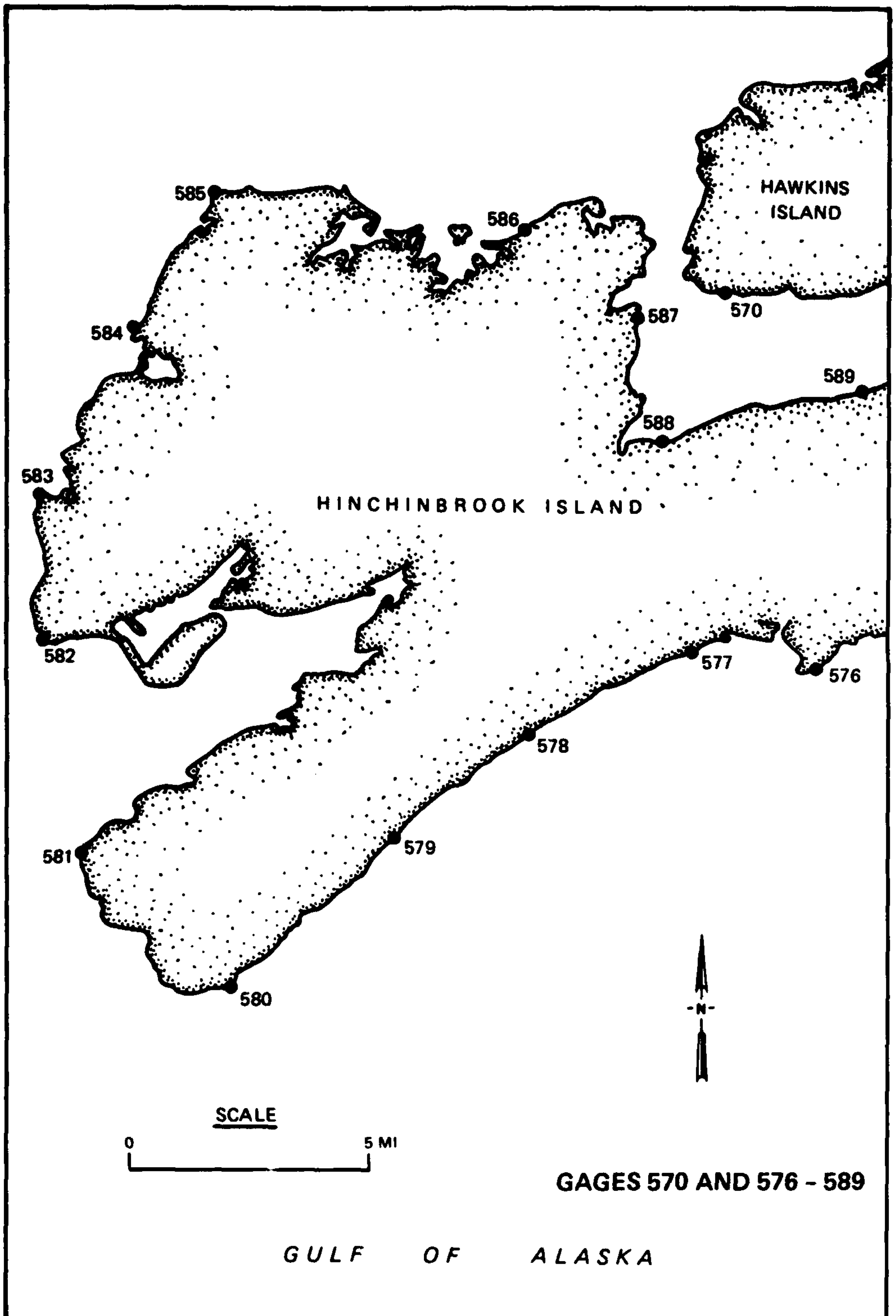

SCALE
0
5 MI
N
543
542
BEARTRAP BAY
544
545
551
552
553
554
555
556
557
558
559
CORDOVA
560
561
562
563
564
SHEEP BAY
566
567
574
HAWKINS ISLAND
573
INLET
ORCA
572
571
GAGES 542 - 545, 551 - 564, 566 AND 567, AND 571 - 575
575
EGG ISLANDS

PLATE 41



HAWKINS ISLAND
585
586
584
587
570
589
588
583
HINCHINBROOK ISLAND
582
577
576
578
581
579
580
N
SCALE
0
5 MI
GAGES 570 AND 576 - 589
GULF OF ALASKA

PLATE 42

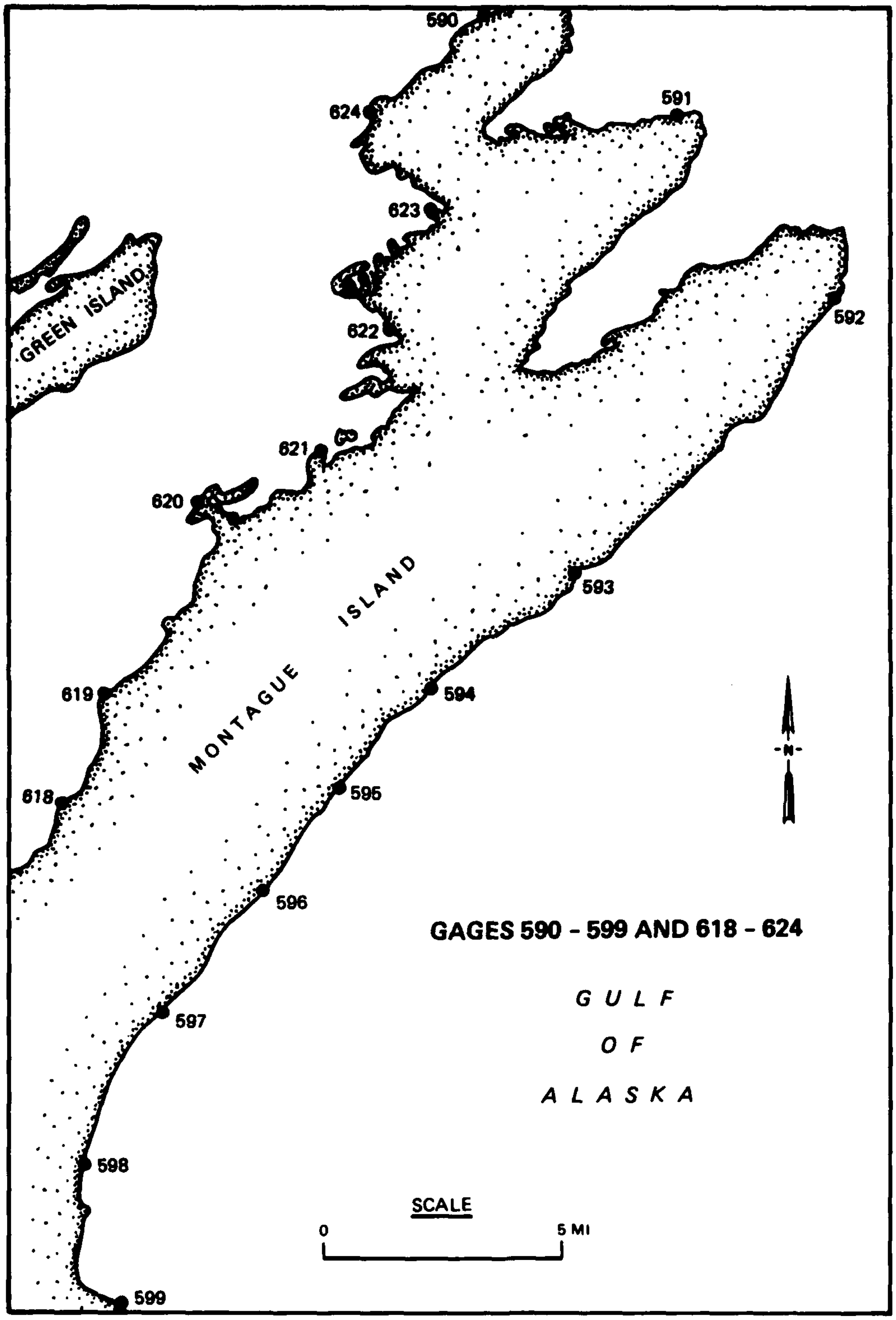

590
591
624
623
GREEN ISLAND
622
592
621
620
MONTAGUE ISLAND
593
619
594
N
618
595
596
GAGES 590 - 599 AND 618 - 624
GULF
OF
ALASKA
597
598
SCALE
0
5 MI
599

PLATE 43

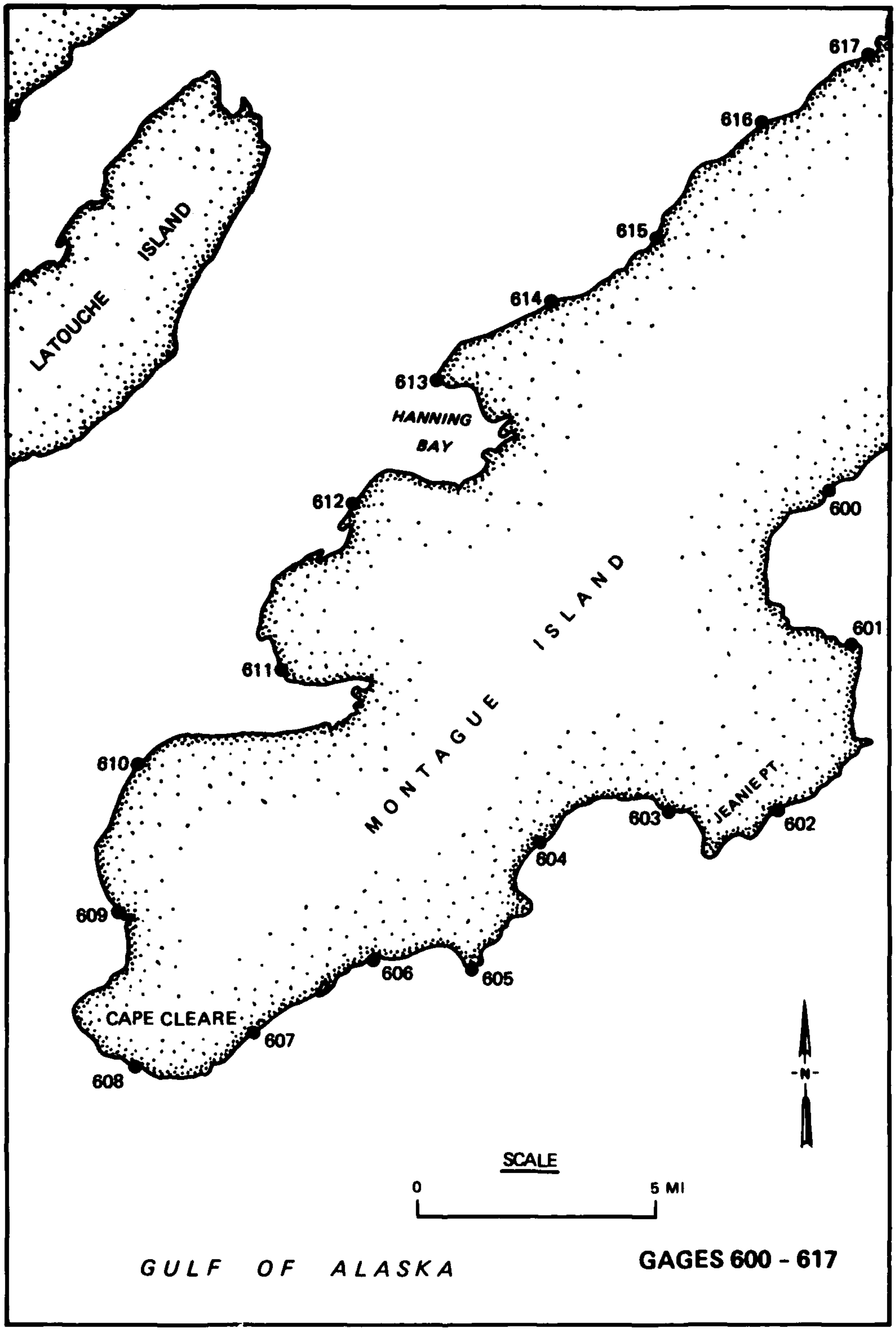

LATOUCHE ISLAND
HANNING BAY
MONTAGUE ISLAND
JEANIE PT.
CAPE CLEARE
617
616
615
614
613
612
611
610
609
608
607
606
605
604
603
602
601
600
N
SCALE
0
5 MI
GULF OF ALASKA
GAGES 600 - 617

PLATE 44

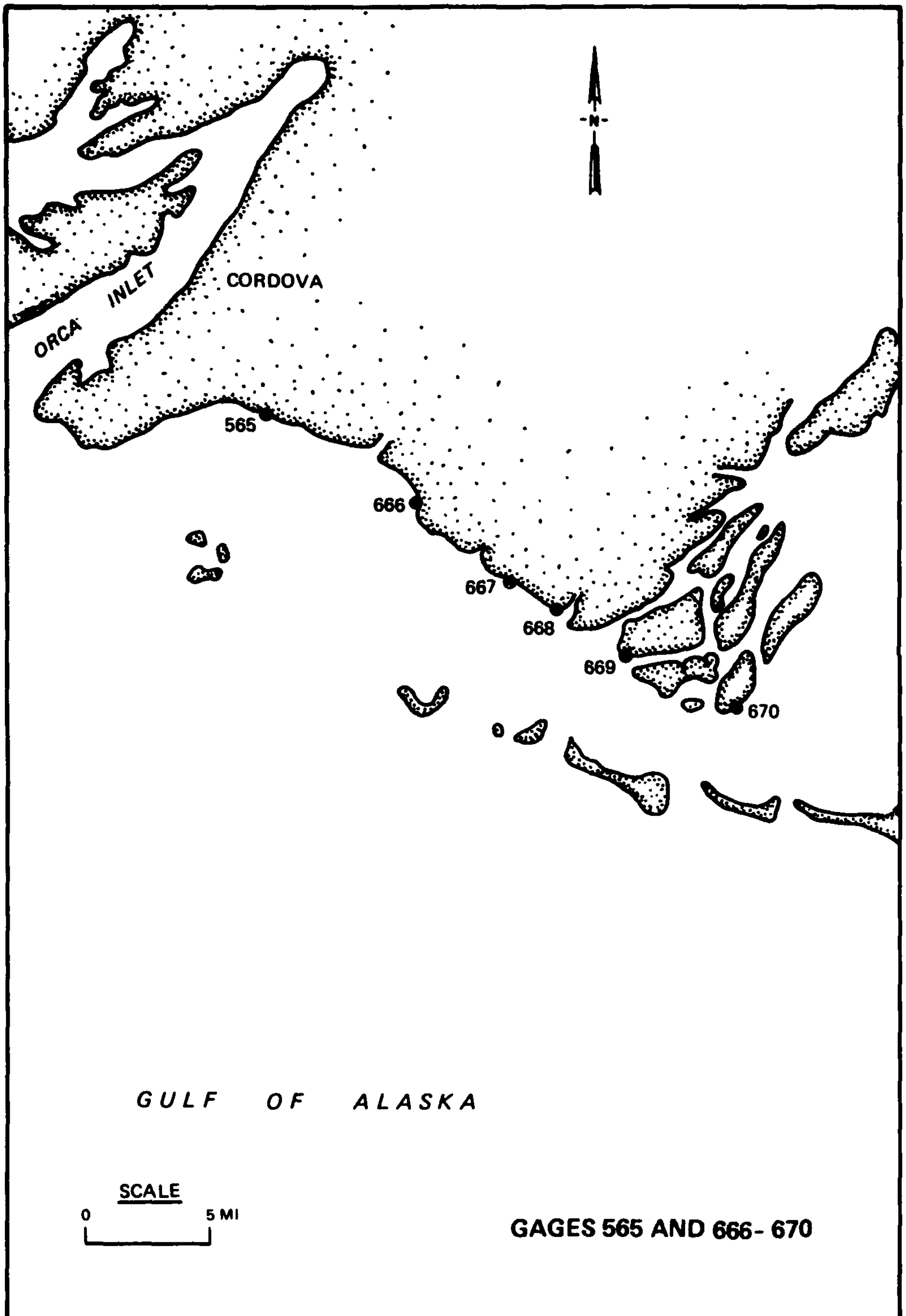
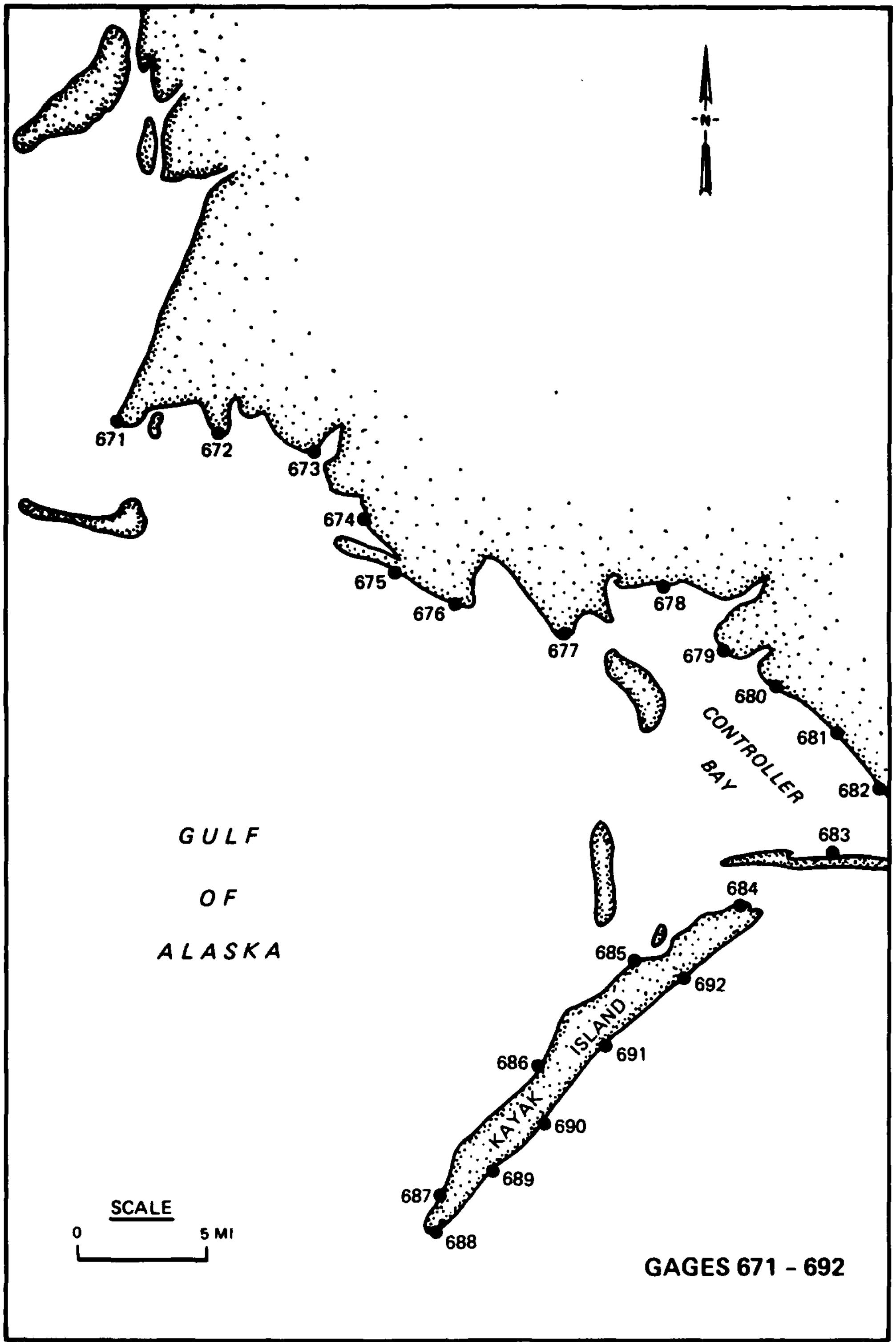
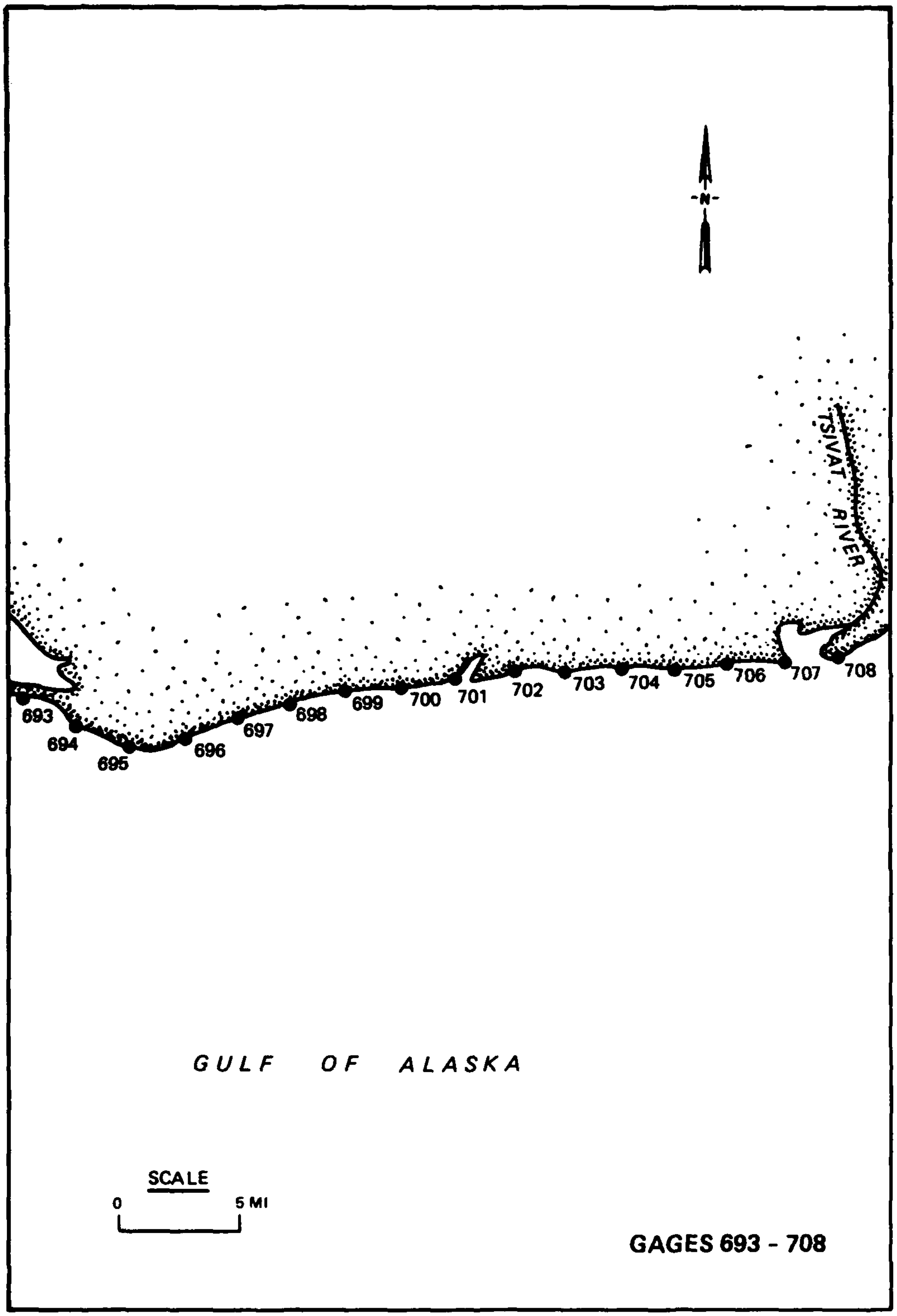

CORDOVA
ORCA INLET
565
666
667
668
669
670
N
GULF OF ALASKA
SCALE
0
5 MI
GAGES 565 AND 666- 670

PLATE 45



671
672
673
674
675
676
677
678
679
680
681
682
683
684
685
686
687
688
689
690
691
692
GULF
OF
ALASKA
CONTROLLER
BAY
KAYAK
ISLAND
N
SCALE
0
5 MI
GAGES 671 - 692

PLATE 46


N
TSIVAT RIVER
693
694
695
696
697
698
699
700
701
702
703
704
705
706
707
708
GULF OF ALASKA
SCALE
0
5 MI
GAGES 693 - 708

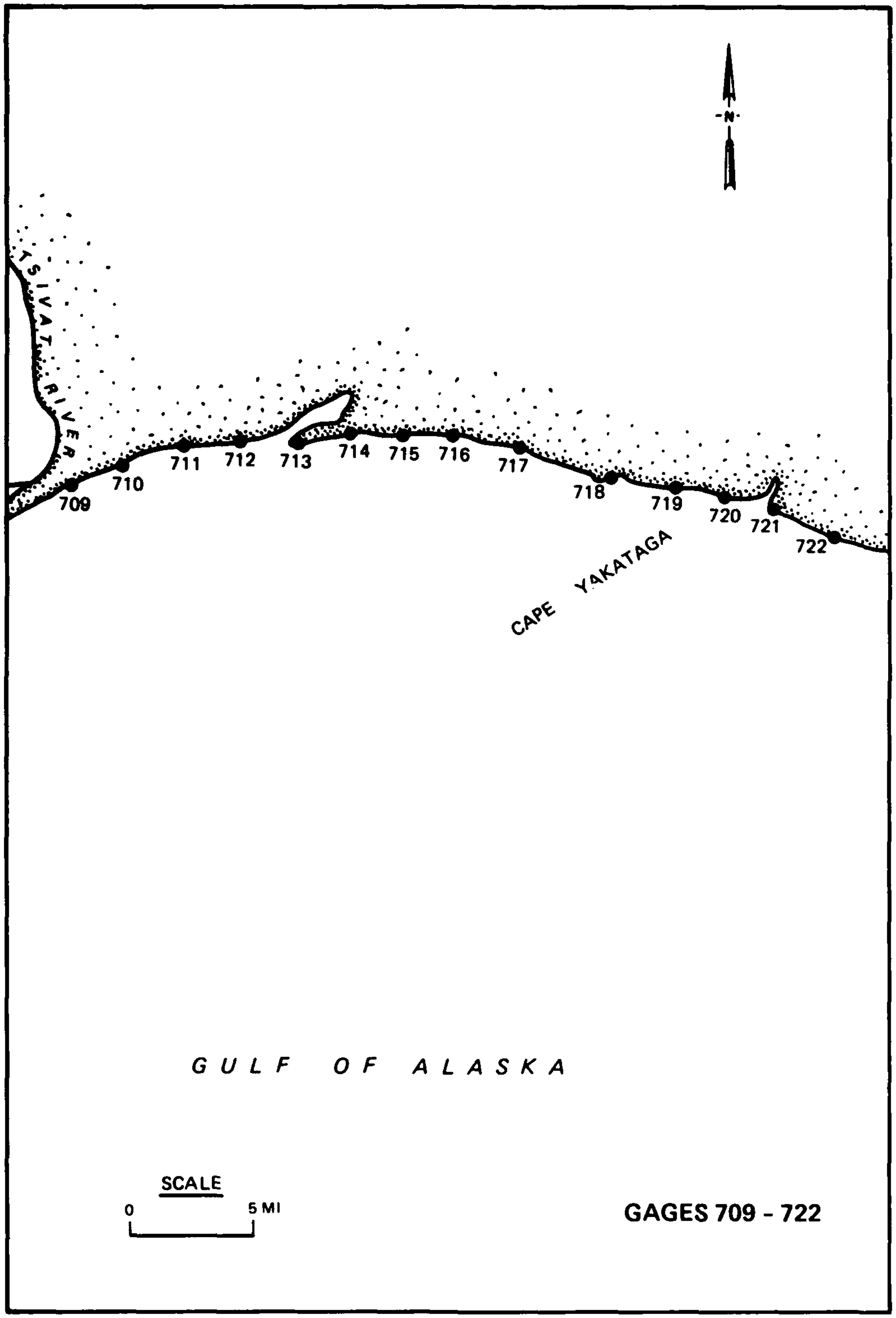

TSIVAT RIVER
709
710
711
712
713
714
715
716
717
718
719
720
721
722
CAPE YAKATAGA
GULF OF ALASKA
SCALE
0
5 MI
N
GAGES 709 - 722

PLATE 48

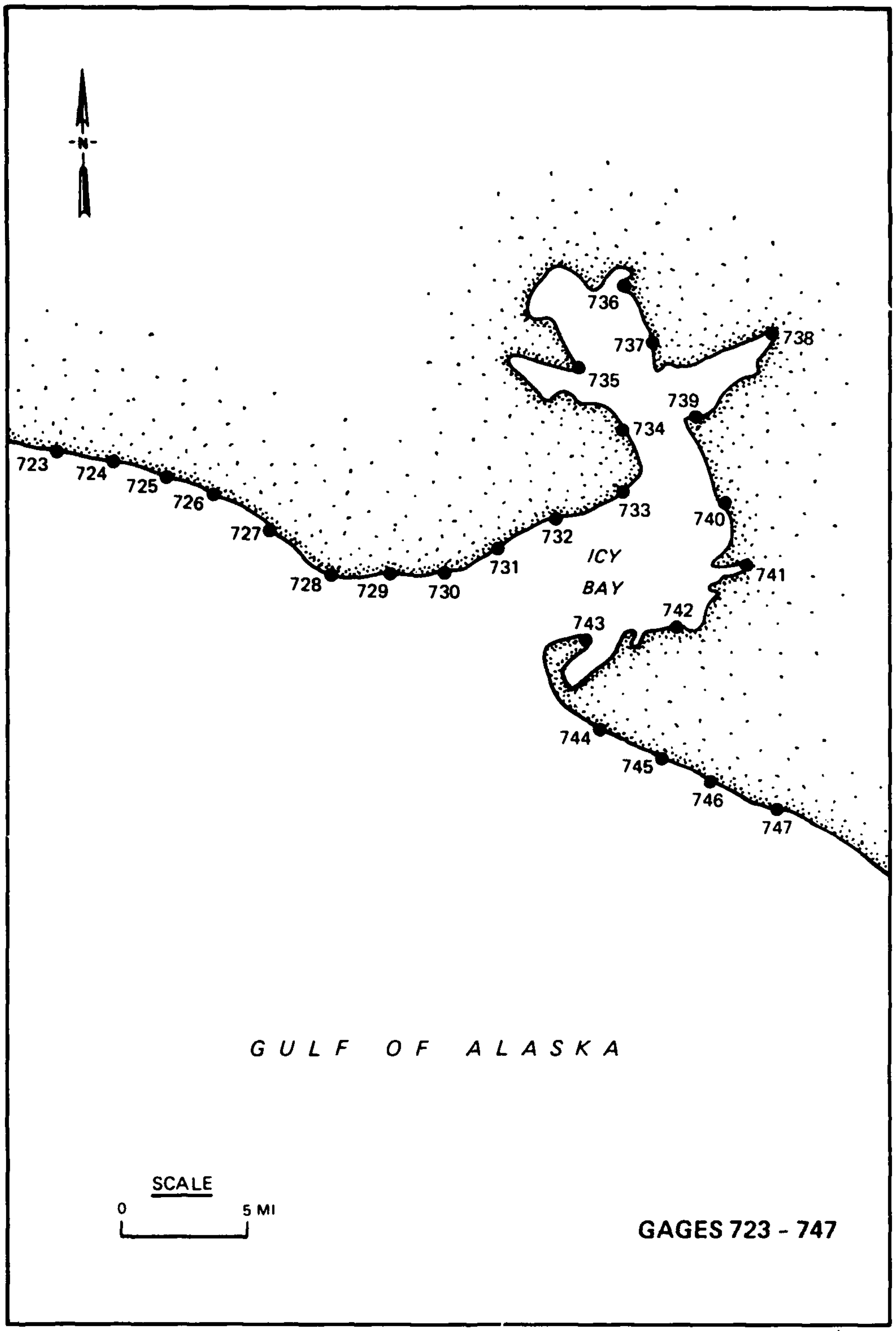

723
724
725
726
727
728
729
730
731
732
733
734
735
736
737
738
739
740
741
742
743
744
745
746
747
ICY
BAY
GULF OF ALASKA
SCALE
0
5 MI
GAGES 723 - 747

PLATE 49

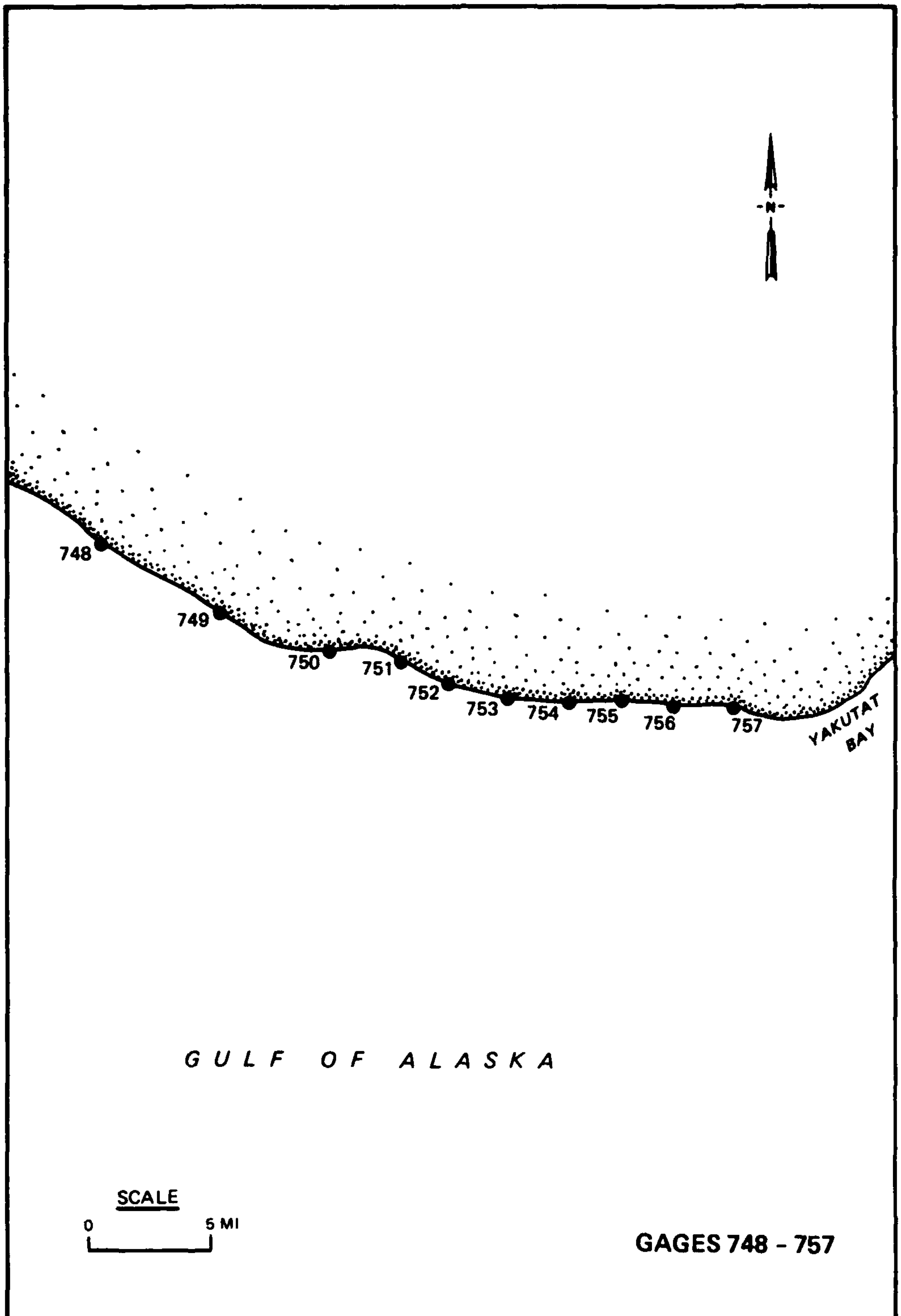

N
748
749
750
751
752
753
754
755
756
757
YAKUTAT BAY
GULF OF ALASKA
SCALE
0
5 MI
GAGES 748 - 757

PLATE 50

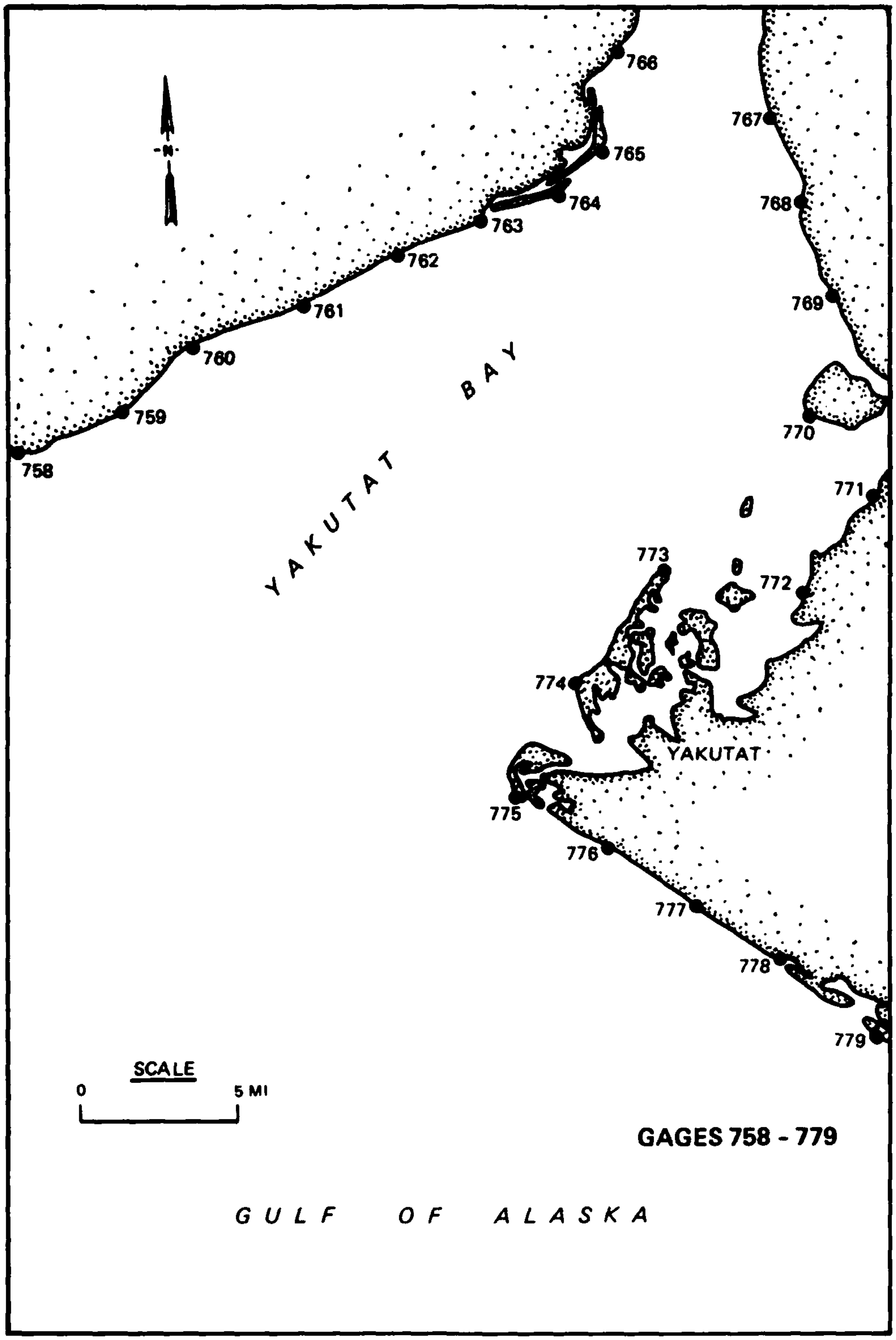
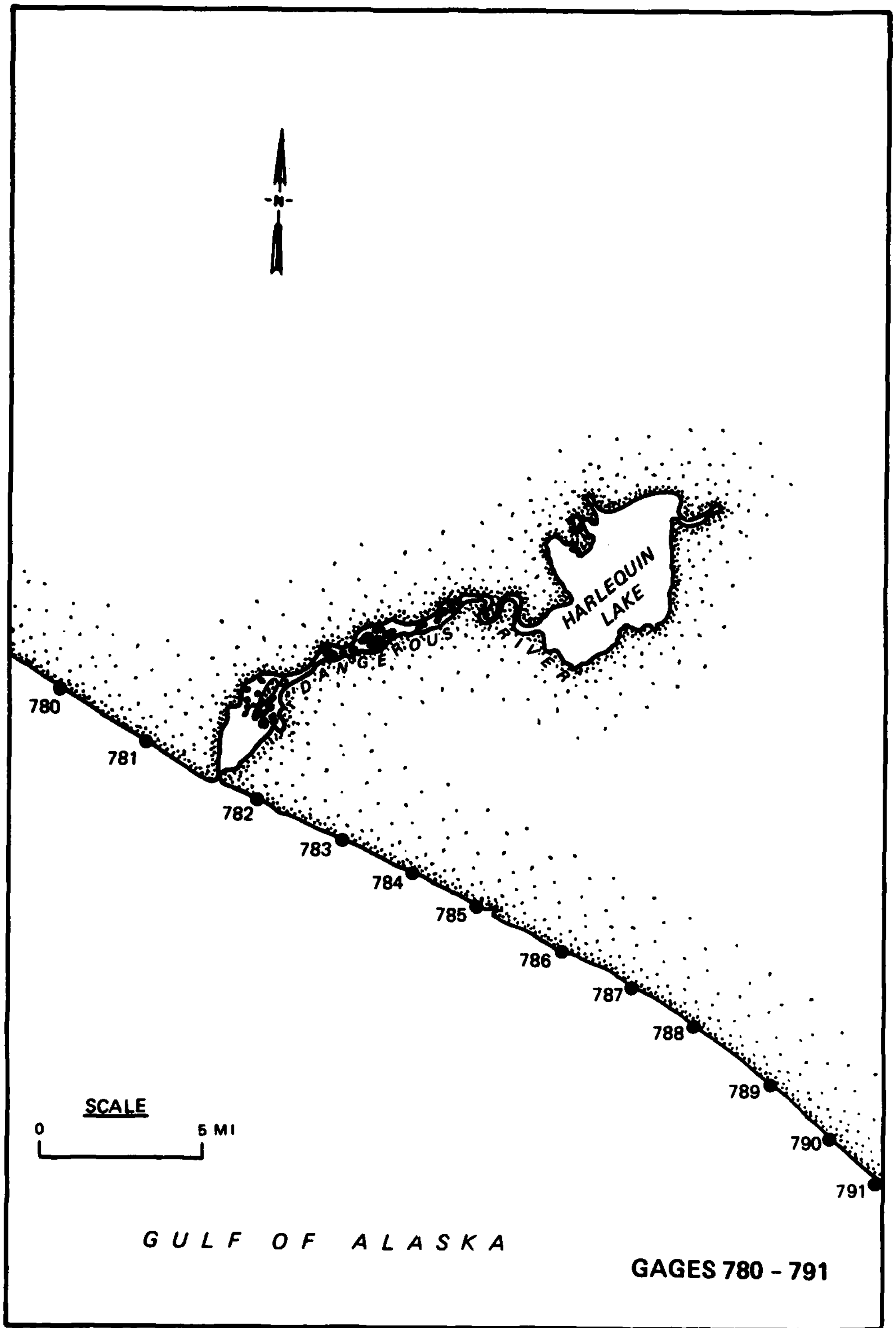
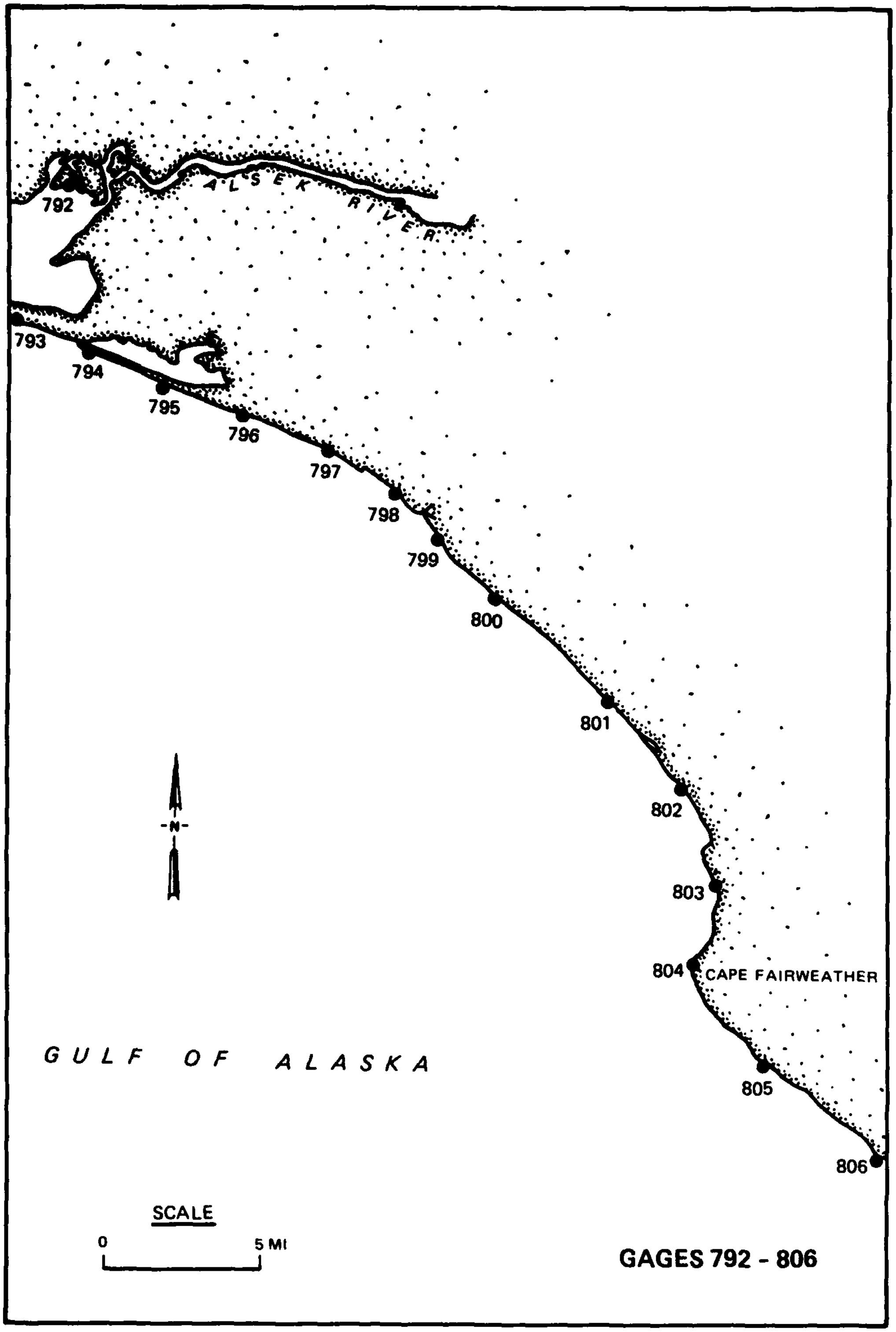

N
766
765
764
763
762
761
760
759
758
767
768
769
770
771
772
773
774
775
776
777
778
779
YAKUTAT BAY
YAKUTAT
SCALE
0
5 MI
GAGES 758 - 779
GULF OF ALASKA

PLATE 51



HARLEQUIN LAKE
DANGEROUS RIVER
780
781
782
783
784
785
786
787
788
789
790
791
SCALE
0
5 MI
GULF OF ALASKA
GAGES 780 - 791

PLATE 52



ALSEK RIVER
792
793
794
795
796
797
798
799
800
801
802
803
804
CAPE FAIRWEATHER
805
806
N
GULF OF ALASKA
SCALE
0
5 MI
GAGES 792 - 806

PLATE 53

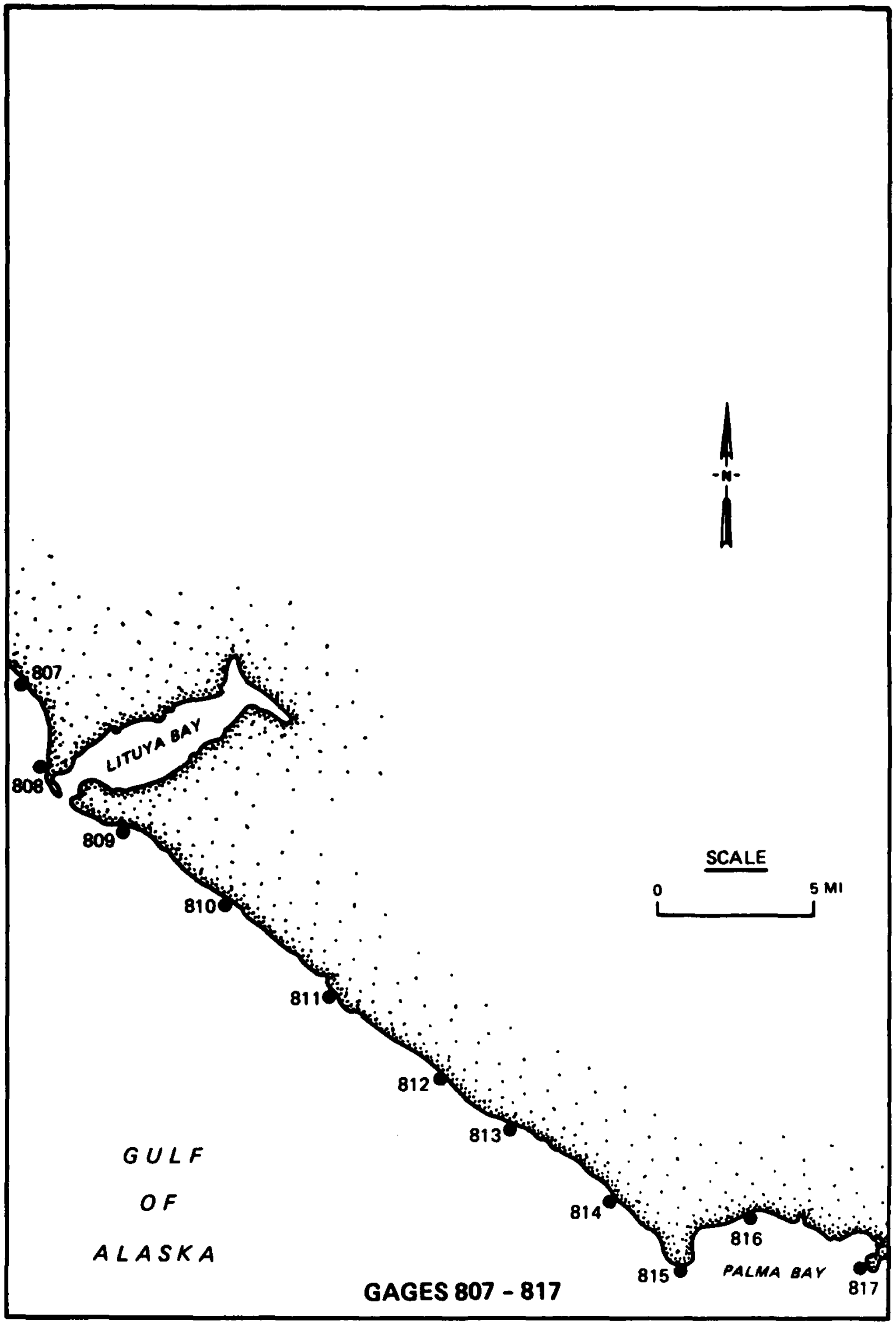
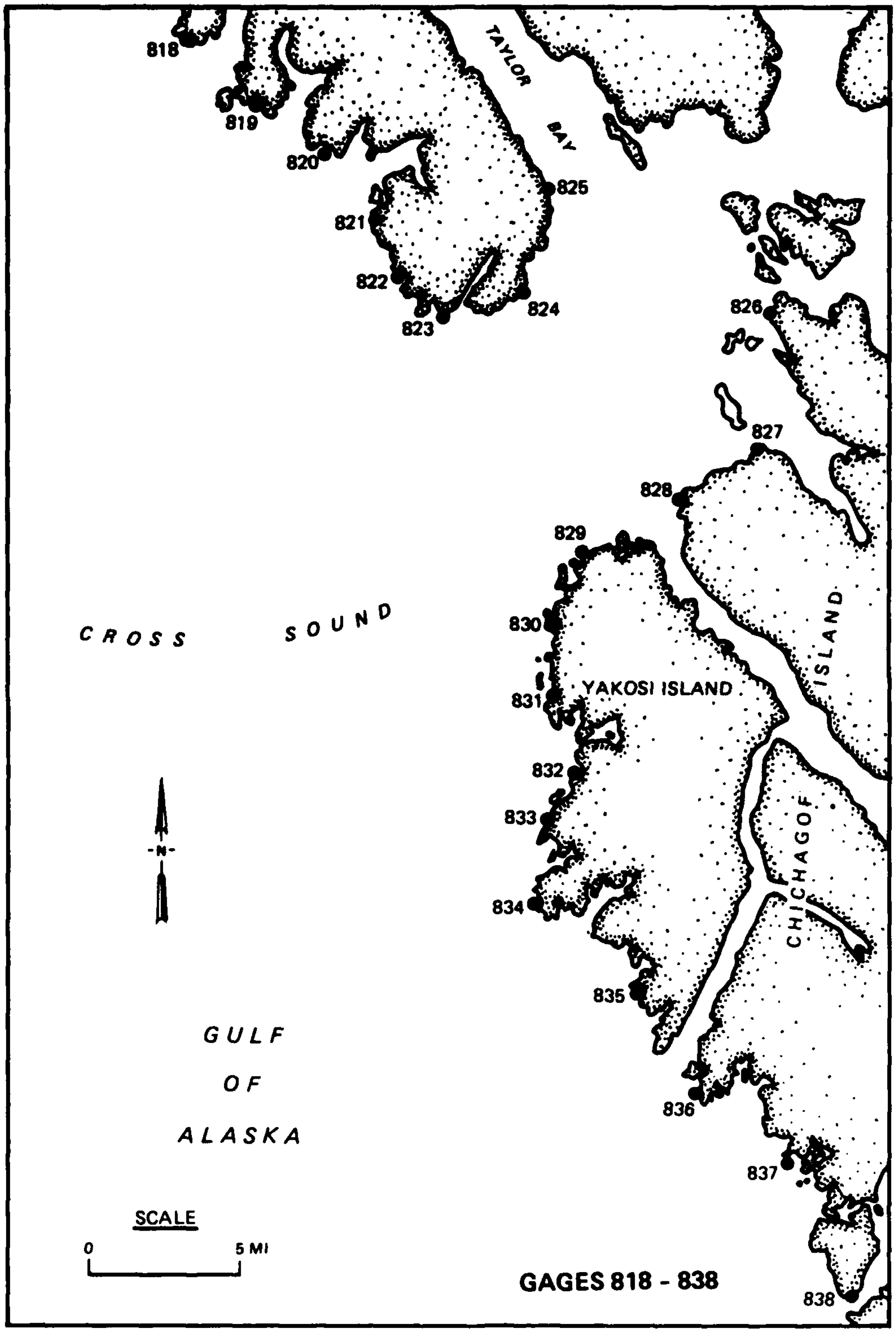

807
808
LITUYA BAY
809
810
811
812
813
814
815
816
817
PALMA BAY
N
SCALE
0
5 MI
GULF
OF
ALASKA
GAGES 807 - 817

PLATE 54



818
819
820
821
822
823
824
825
TAYLOR
BAY
826
827
828
829
830
831
832
833
834
835
836
837
838
CROSS SOUND
YAKOSI ISLAND
CHICHAGOF ISLAND
N
GULF
OF
ALASKA
SCALE
0
5 MI
GAGES 818 - 838

PLATE 55

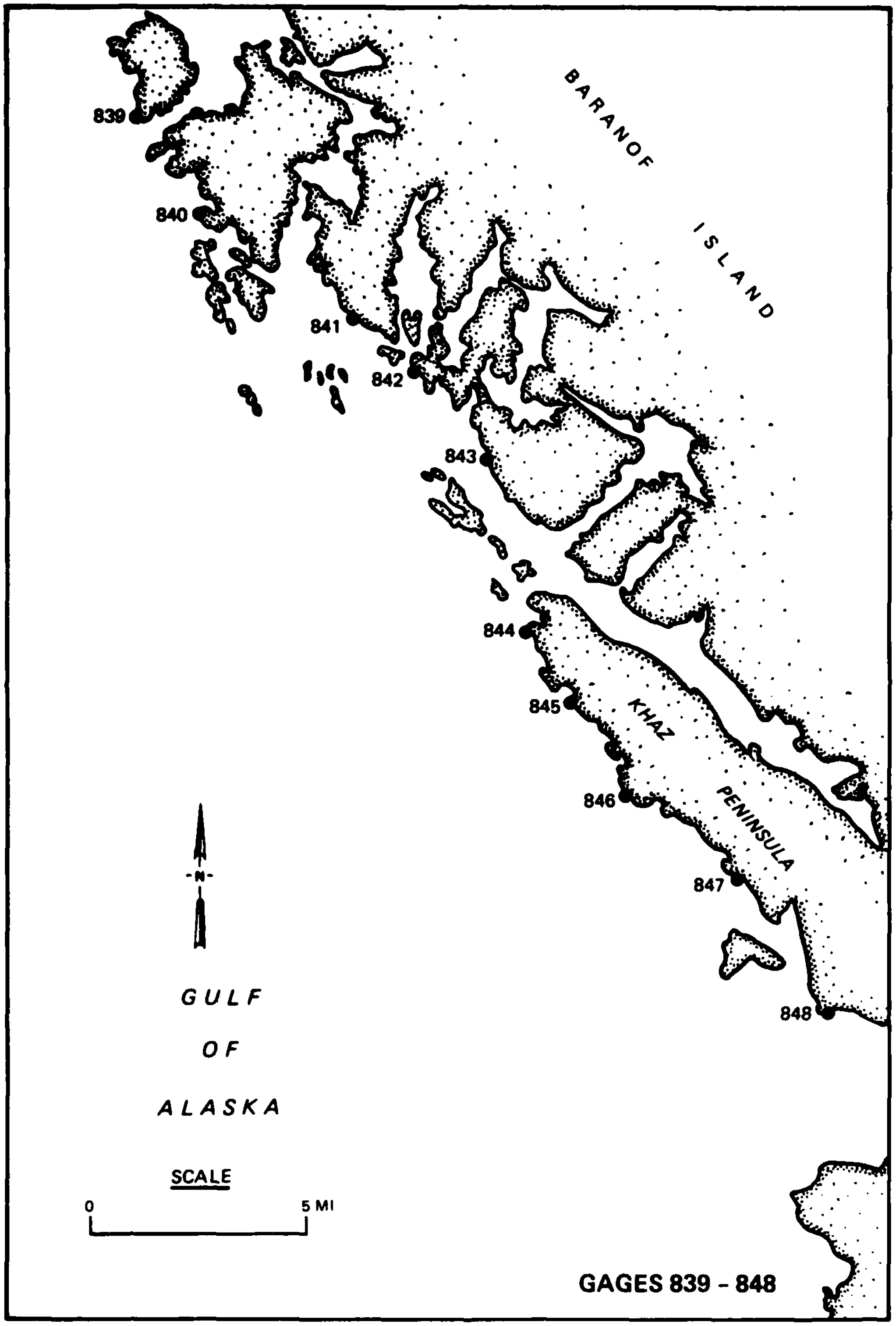

BARANOF ISLAND
839
840
841
842
843
844
845
846
847
848
KHAZ PENINSULA
N
GULF OF ALASKA
SCALE
0
5 MI
GAGES 839 - 848

PLATE 56

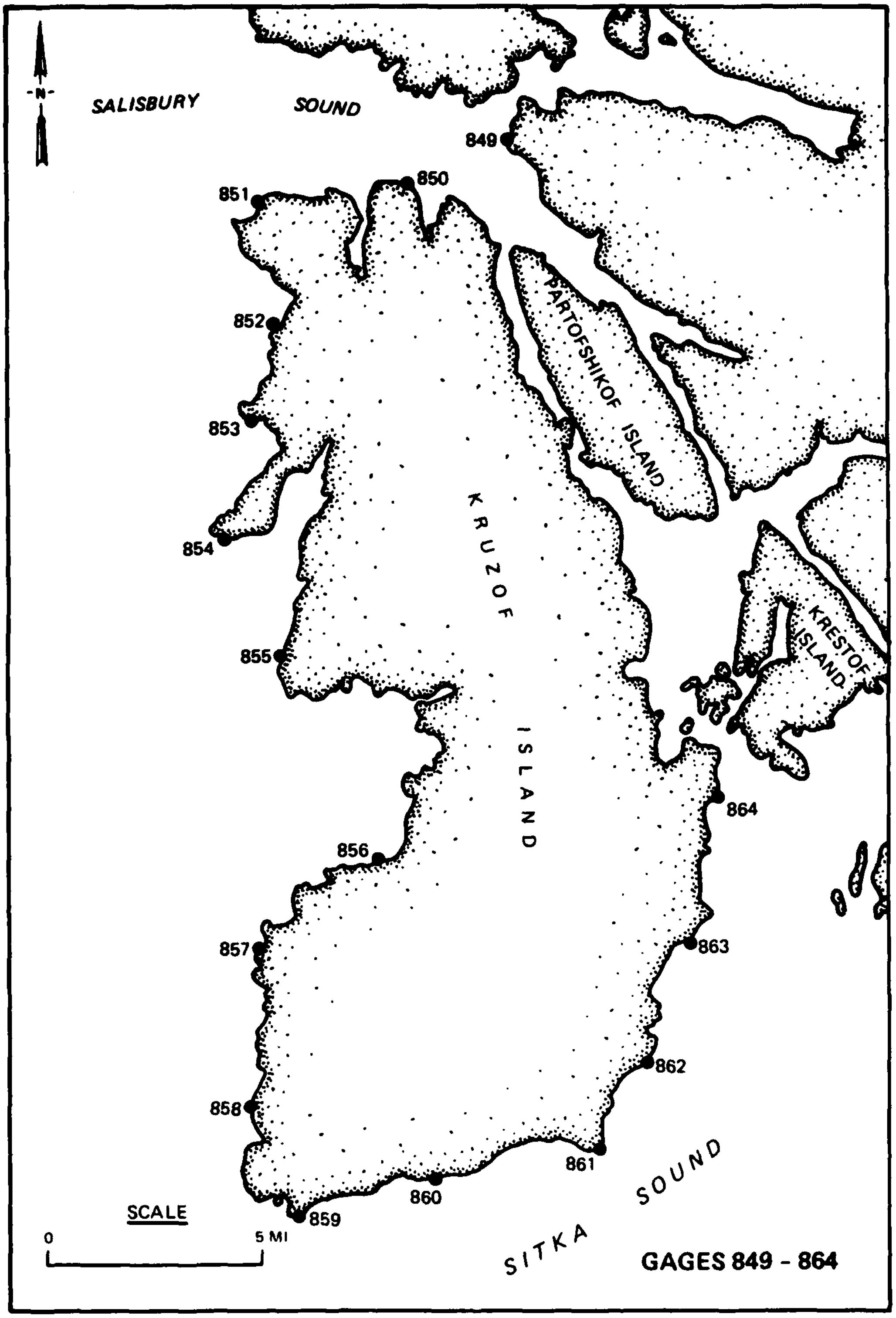

N
SALISBURY
SOUND
849
850
851
852
853
854
855
856
857
858
859
860
861
862
863
864
PARTOFSHIKOF ISLAND
KRUZOF
ISLAND
KRESTOF ISLAND
SCALE
0
5 MI
SITKA SOUND
GAGES 849 - 864

PLATE 57

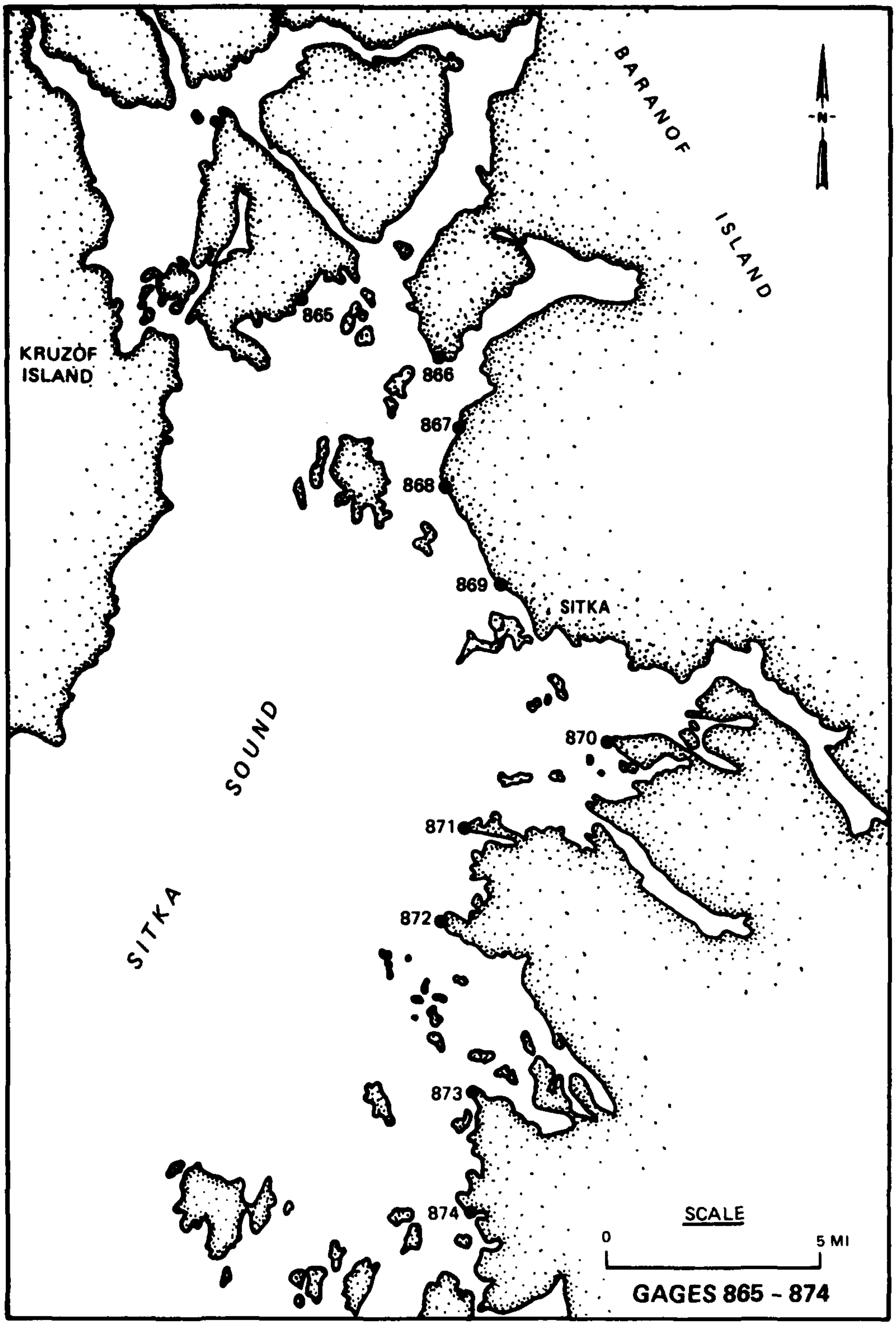

BARANOF
ISLAND
N
KRUZOF
ISLAND
865
866
867
868
869
SITKA
870
871
872
873
874
SITKA
SOUND
SCALE
0
5 MI
GAGES 865 - 874

PLATE 58

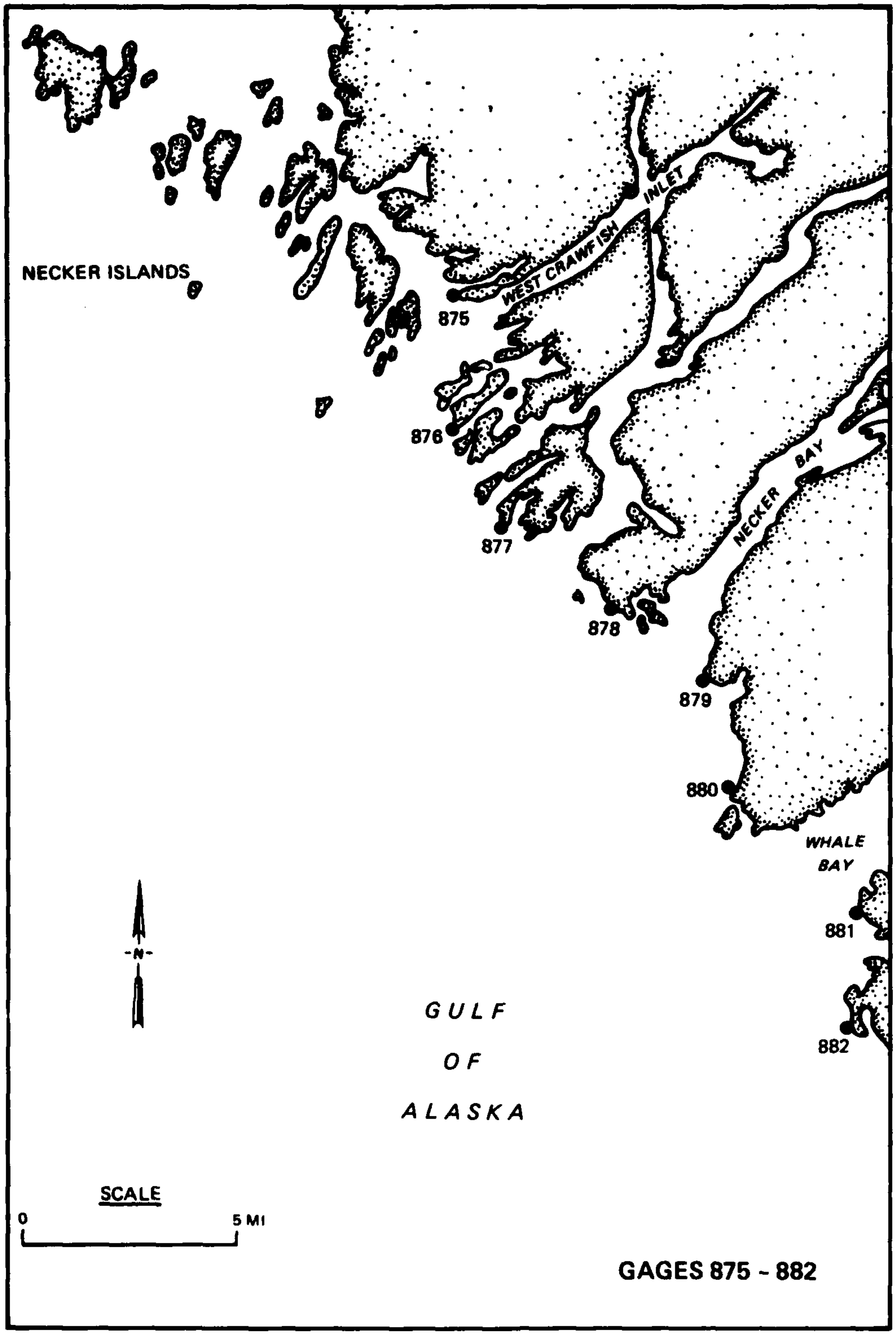

NECKER ISLANDS
WEST CRAWFISH INLET
875
876
877
878
NECKER BAY
879
880
WHALE BAY
881
882
N
GULF OF ALASKA
SCALE
0
5 MI
GAGES 875 - 882

PLATE 59

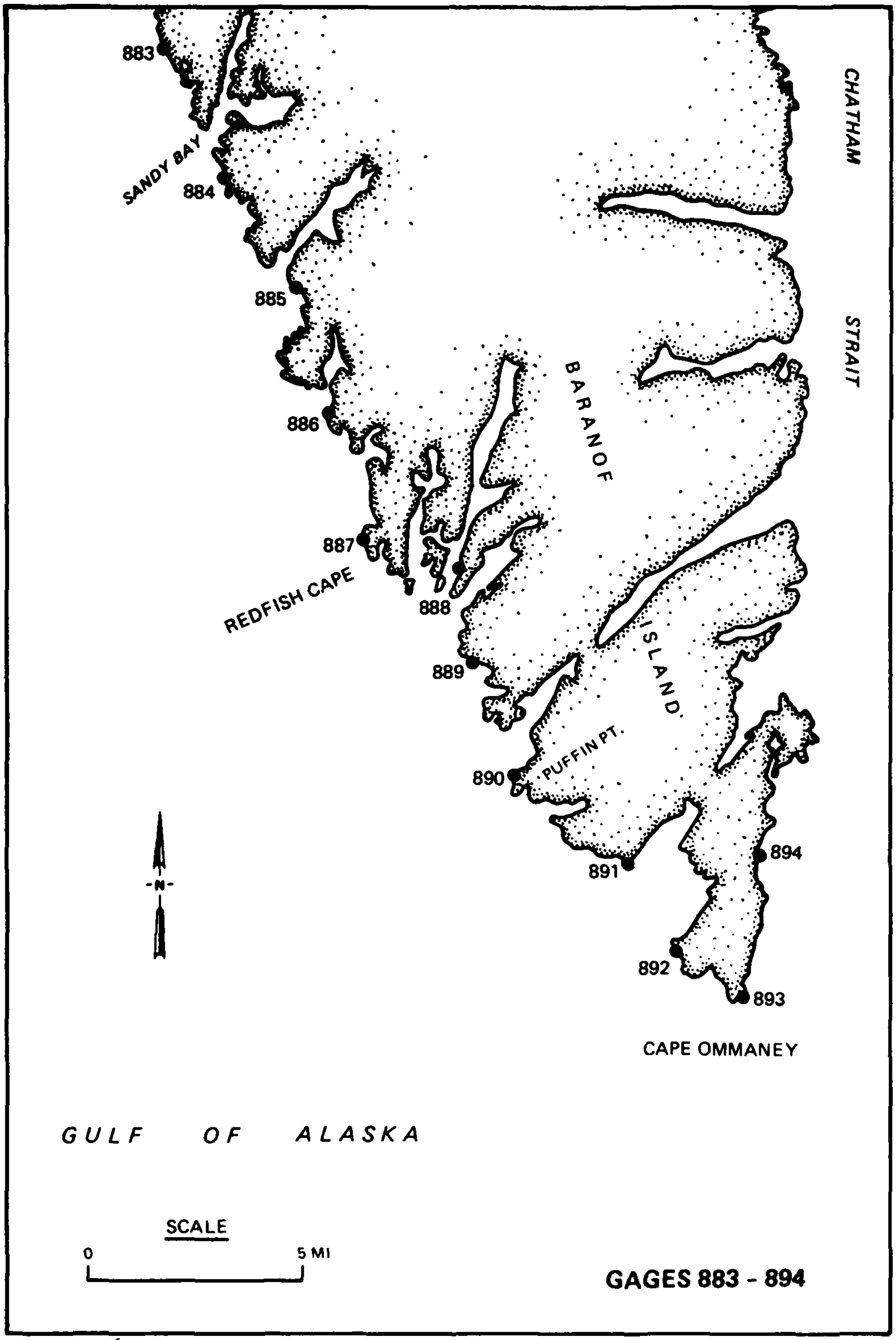

883
SANDY BAY
884
885
886
887
REDFISH CAPE
888
889
890
PUFFIN PT.
891
892
893
894
CAPE OMMANEY
BARANOF
ISLAND
CHATHAM
STRAIT
N
GULF OF ALASKA
SCALE
0
5 MI
GAGES 883 - 894

PLATE 60

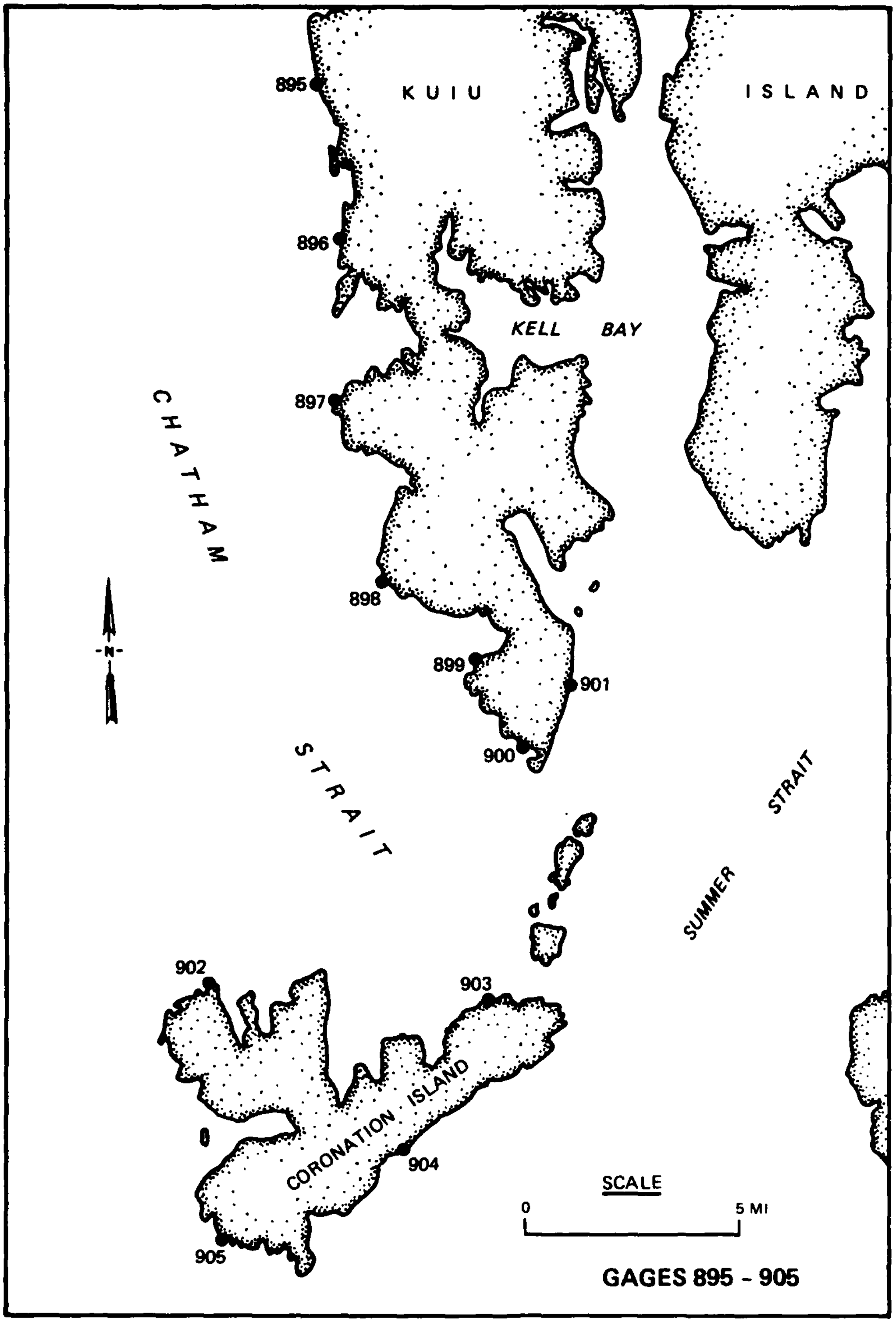
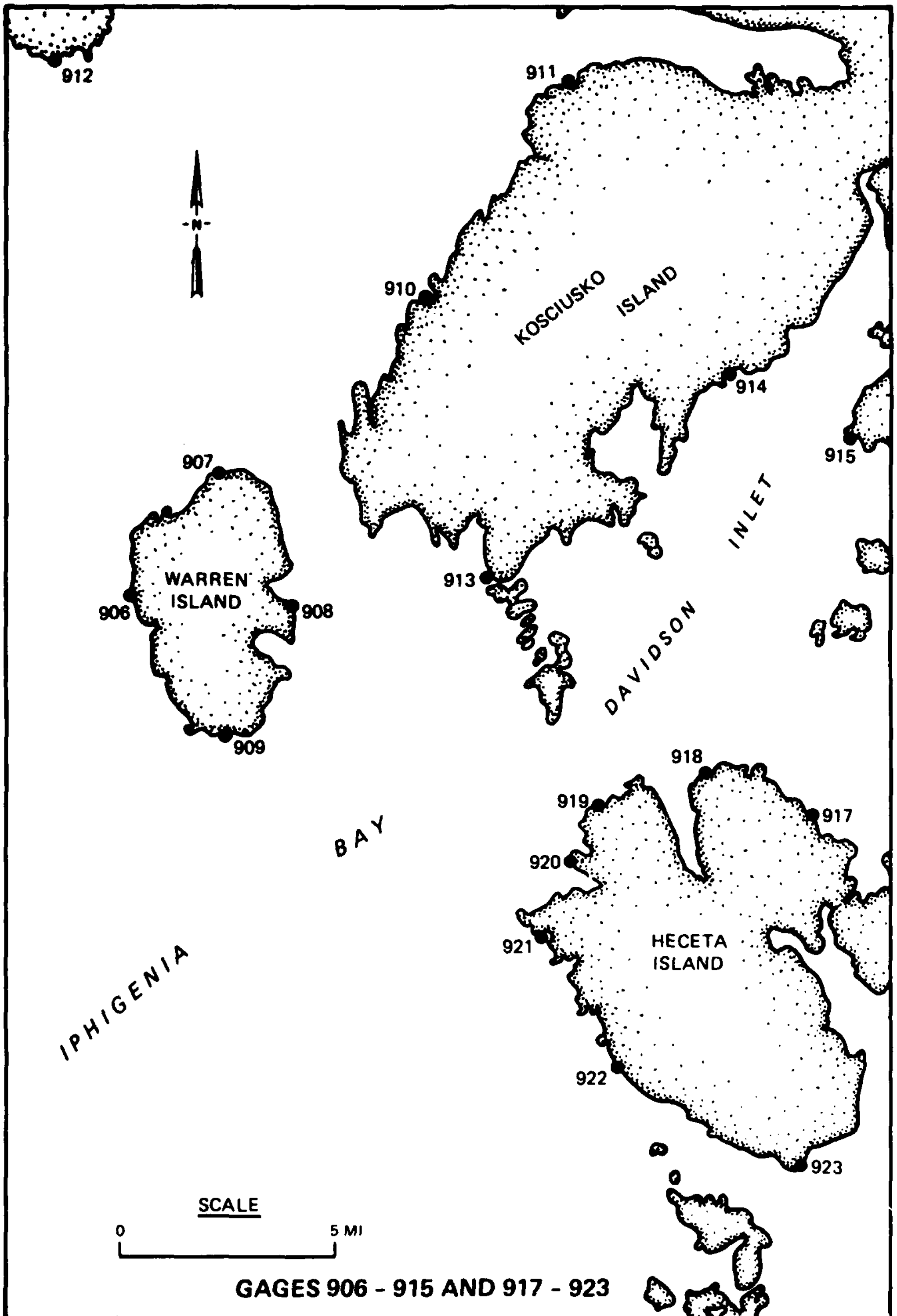

KUIU
ISLAND
895
896
KELL BAY
897
CHATHAM
898
N
899
901
900
STRAIT
SUMMER
STRAIT
902
903
CORONATION ISLAND
904
905
SCALE
0
5 MI
GAGES 895 - 905

PLATE 61



912
911
910
KOSCIUSKO ISLAND
914
915
907
WARREN ISLAND
906
908
909
913
INLET
DAVIDSON
BAY
IPHIGENIA
918
919
917
920
921
HECETA ISLAND
922
923
SCALE
0
5 MI
GAGES 906 - 915 AND 917 - 923

PLATE 62

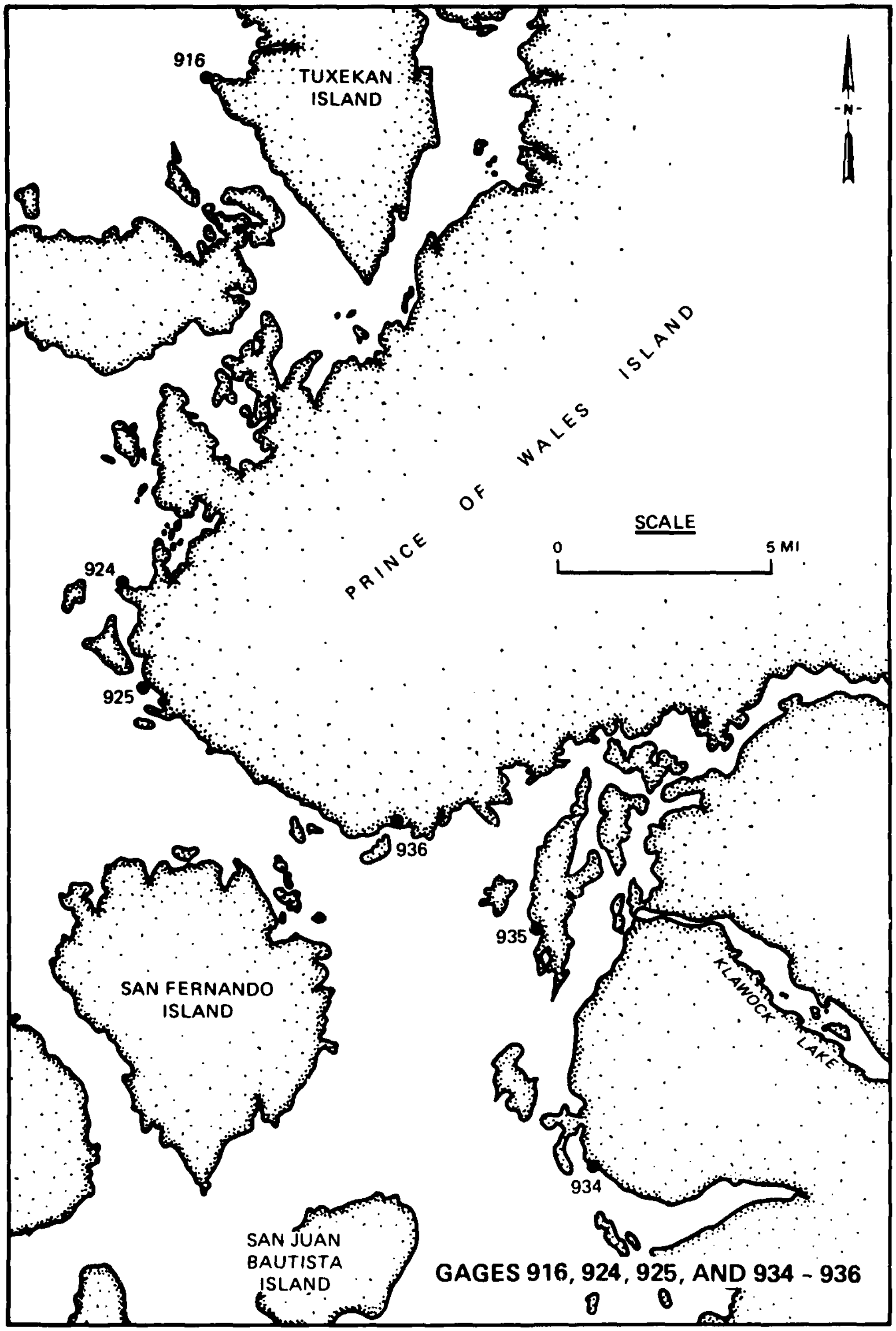

916
TUXEKAN ISLAND
PRINCE OF WALES ISLAND
SCALE
0
5 MI
N
924
925
936
935
SAN FERNANDO ISLAND
KLAWOCK LAKE
934
SAN JUAN BAUTISTA ISLAND
GAGES 916, 924, 925, AND 934 - 936

PLATE 63

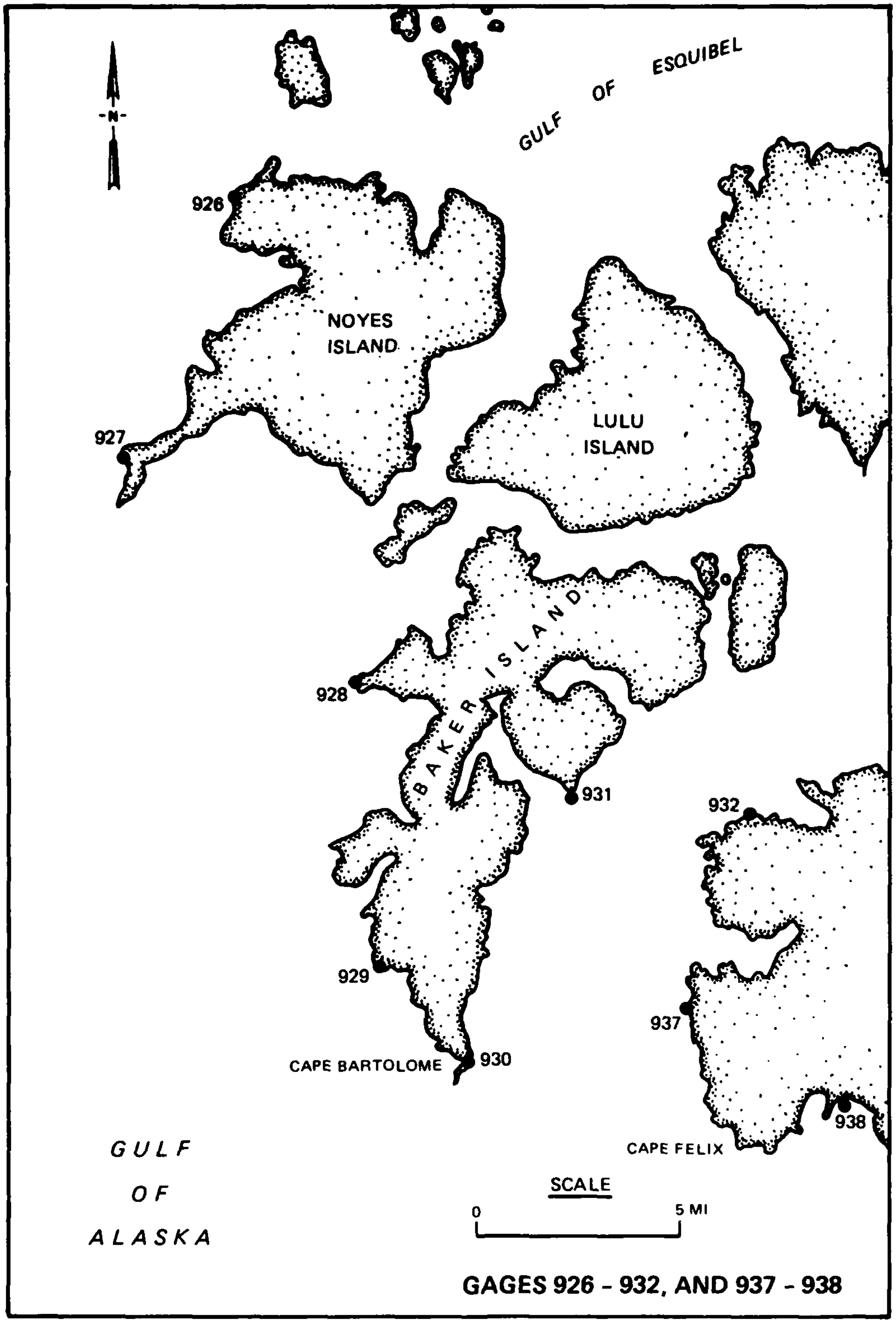
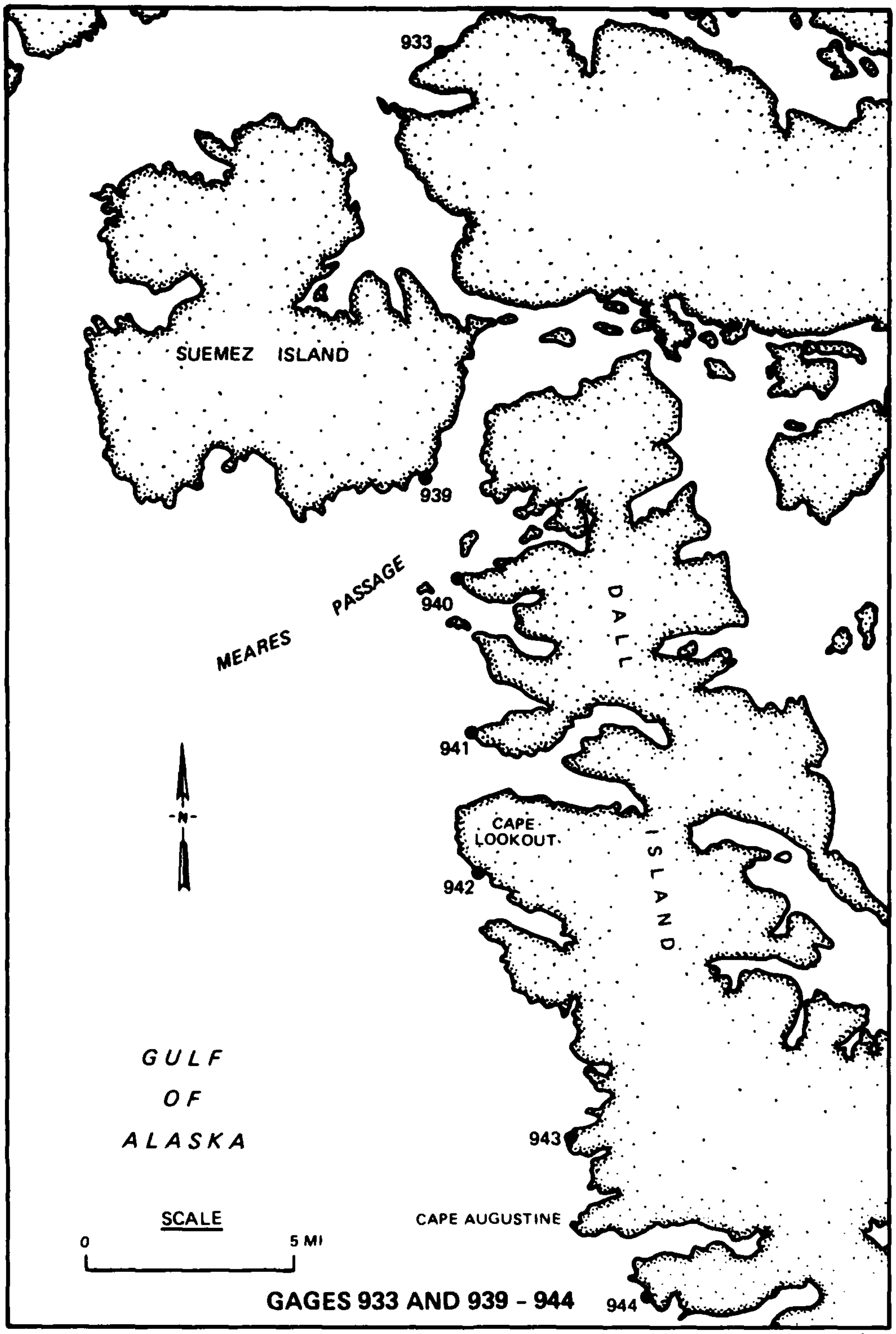

GULF OF ESQUIBEL
N
926
NOYES ISLAND
927
LULU ISLAND
BAKER ISLAND
928
931
932
929
937
CAPE BARTOLOME
930
938
CAPE FELIX
GULF OF ALASKA
SCALE
0
5 MI
GAGES 926 - 932, AND 937 - 938

PLATE 64



GAGES 933 AND 939 - 944

PLATE 65

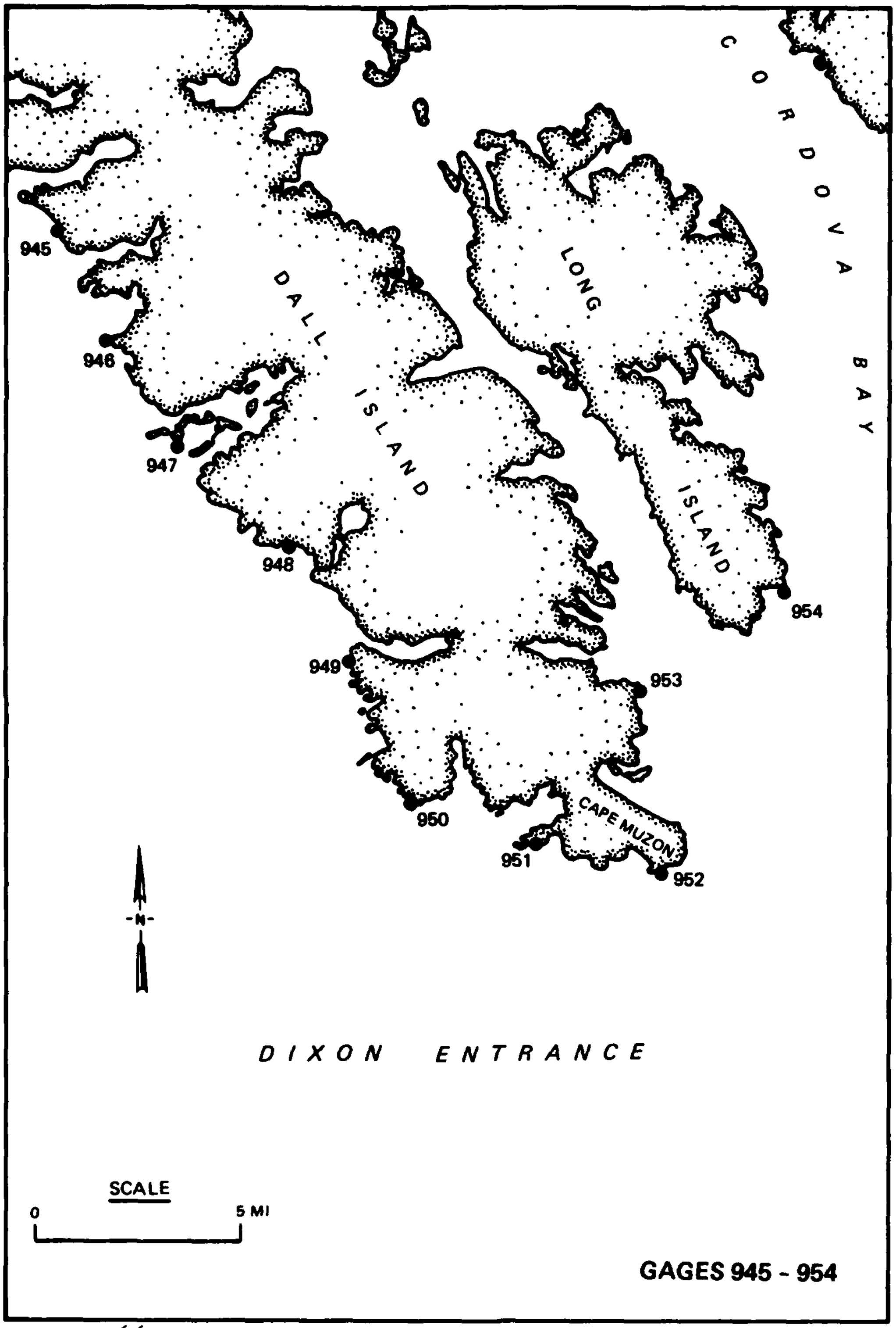

CORDOVA BAY
LONG ISLAND
DALL ISLAND
CAPE MUZON
945
946
947
948
949
950
951
952
953
954
N
DIXON ENTRANCE
SCALE
0
5 MI
GAGES 945 - 954

PLATE 66

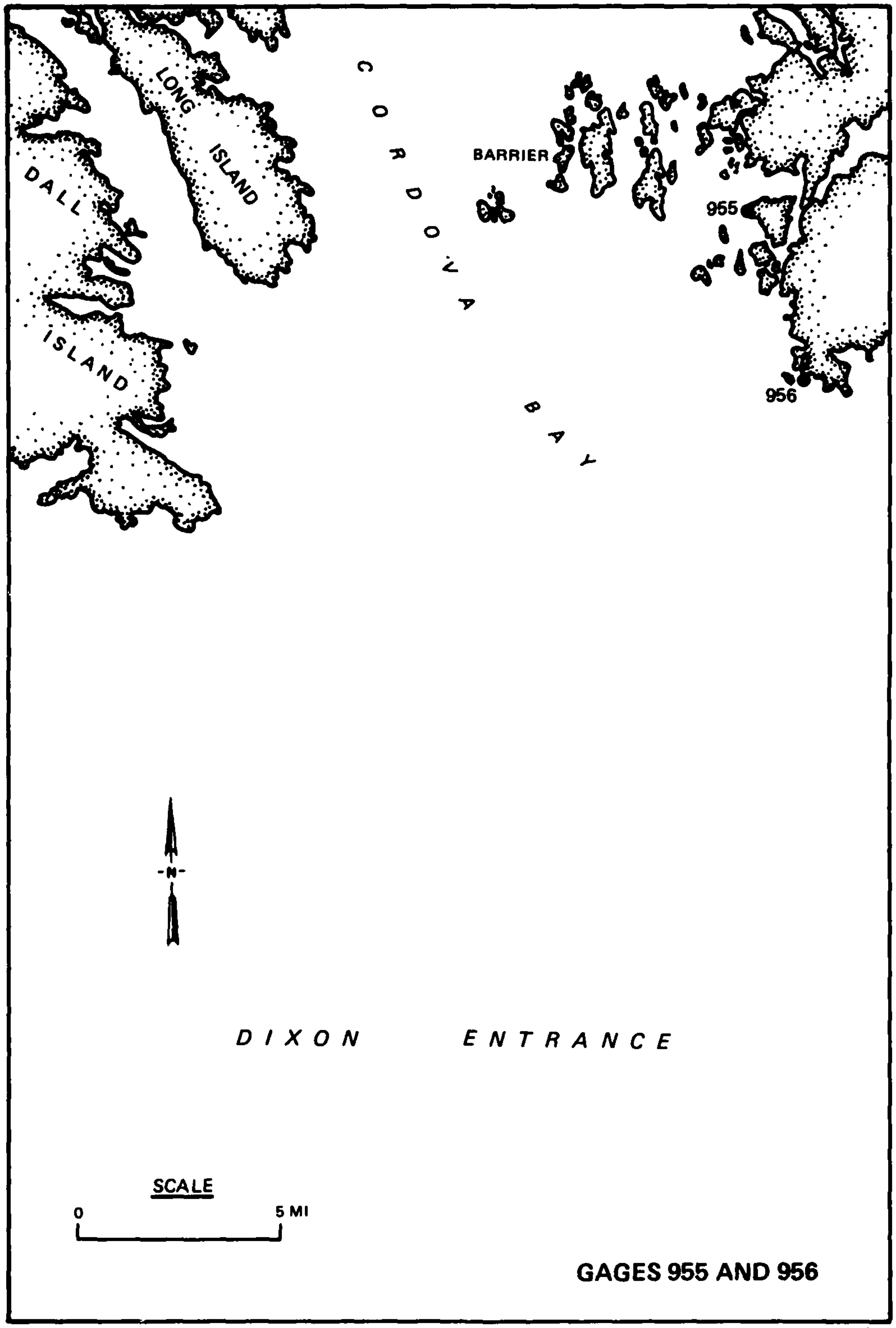

LONG ISLAND
DALL ISLAND
CORDOVA BAY
BARRIER
955
956
DIXON ENTRANCE
-N-
SCALE
0
5 MI
GAGES 955 AND 956

PLATE 67

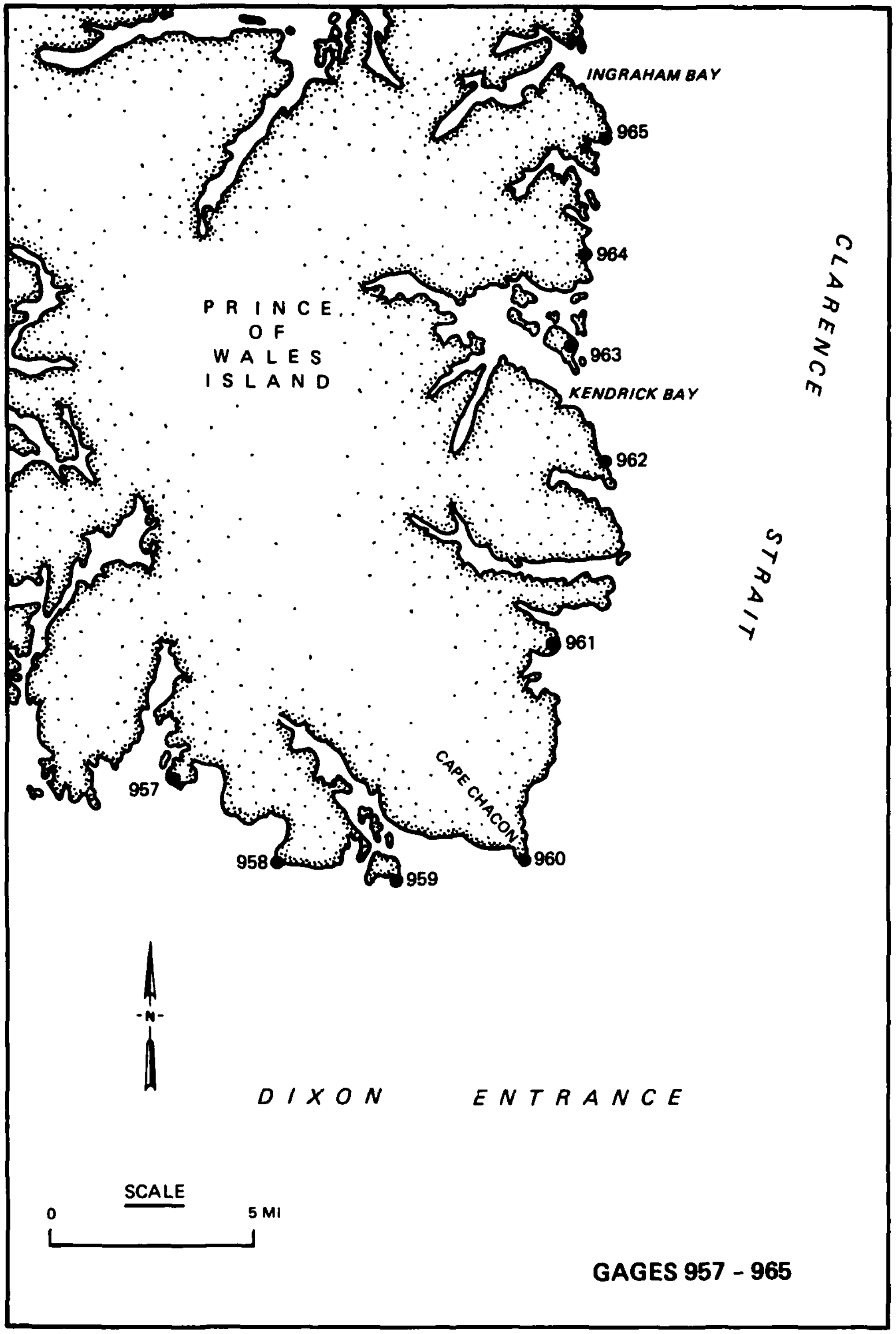

INGRAHAM BAY
965
964
PRINCE
OF
WALES
ISLAND
963
KENDRICK BAY
CLARENCE
962
STRAIT
961
CAPE CHACON
957
958
959
960
-N-
DIXON ENTRANCE
SCALE
0
5 MI
GAGES 957 - 965

PLATE 68

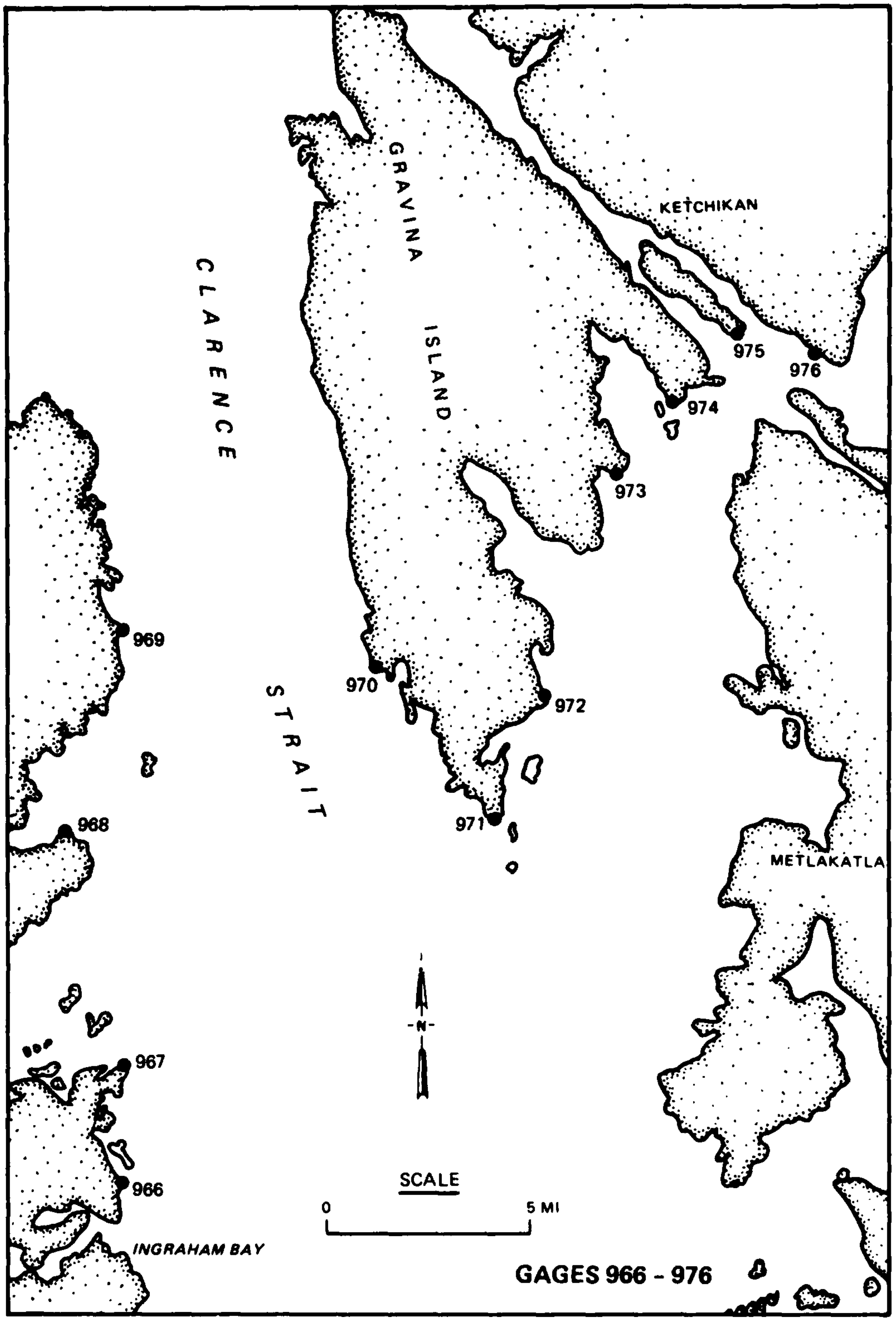

GRAVINA
ISLAND
KETCHIKAN
CLARENCE
STRAIT
METLAKATLA
INGRAHAM BAY
966
967
968
969
970
971
972
973
974
975
976
N
SCALE
0
5 MI
GAGES 966 - 976

PLATE 69

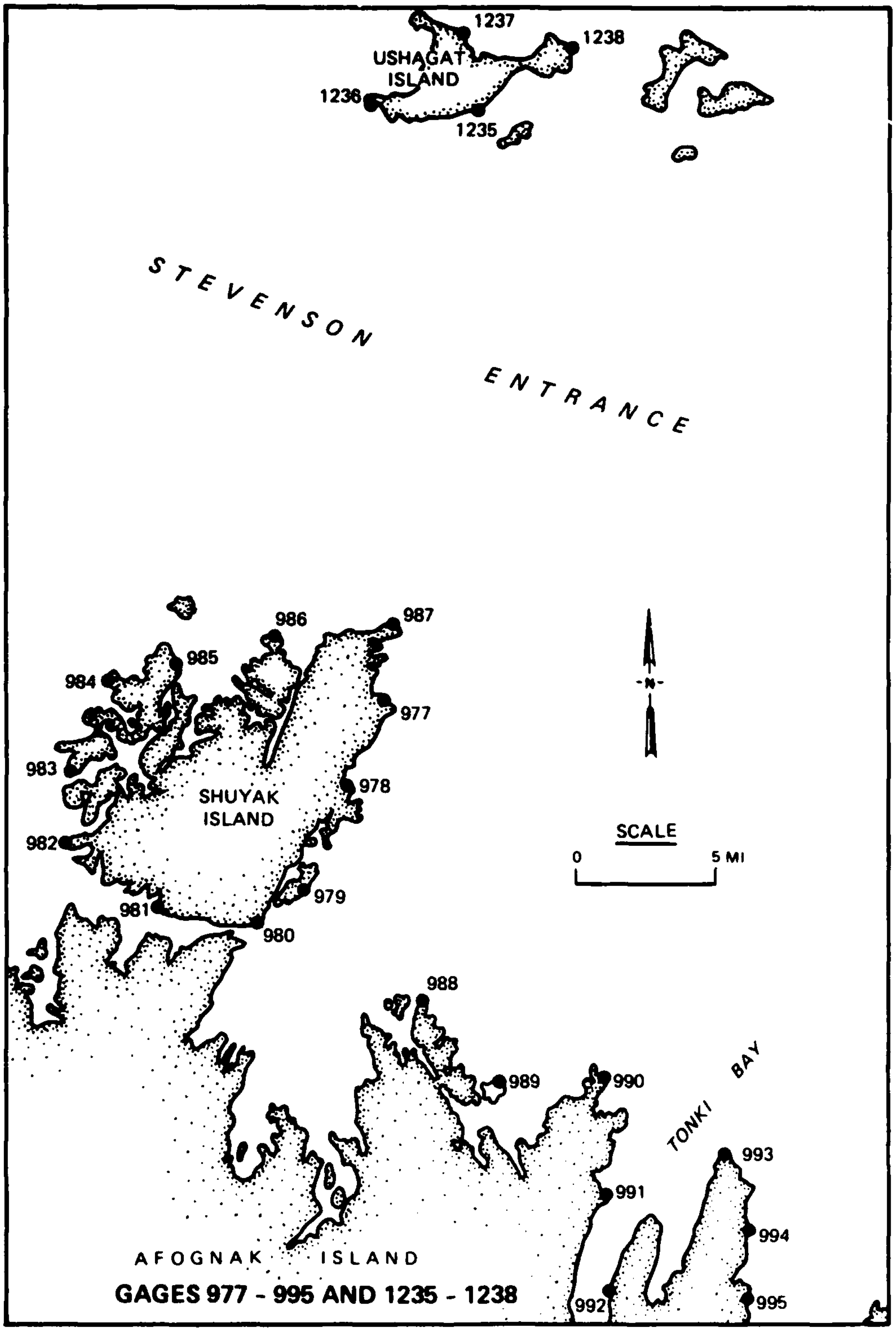
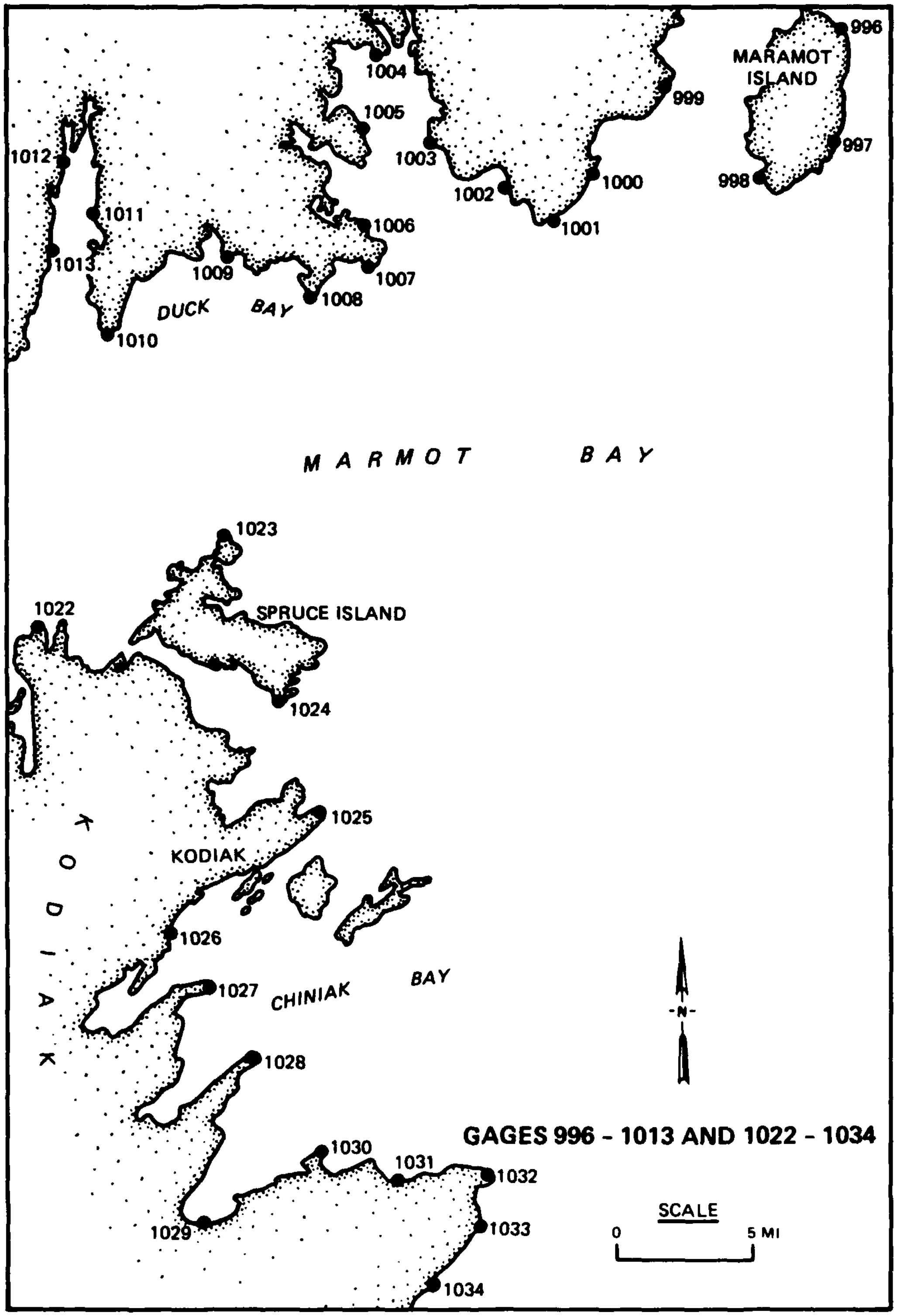

1237
1238
USHAGAT
ISLAND
1236
1235
STEVENSON
ENTRANCE
986
987
985
984
977
983
978
SHUYAK
ISLAND
982
SCALE
0
5 MI
979
981
980
988
989
990
TONKI BAY
993
991
994
AFOGNAK ISLAND
GAGES 977 - 995 AND 1235 - 1238
992
995

PLATE 70



GAGES 996 - 1013 AND 1022 - 1034

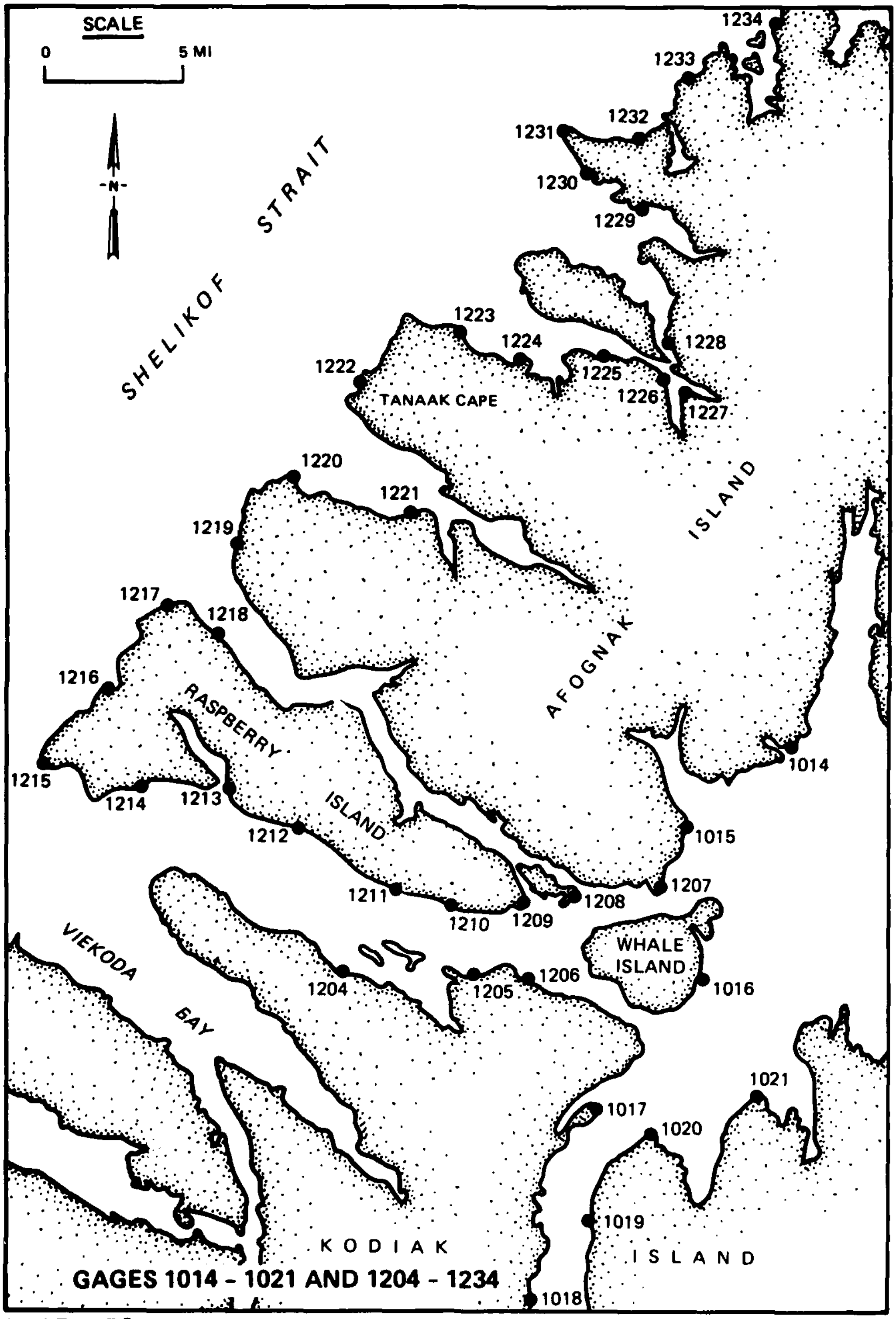
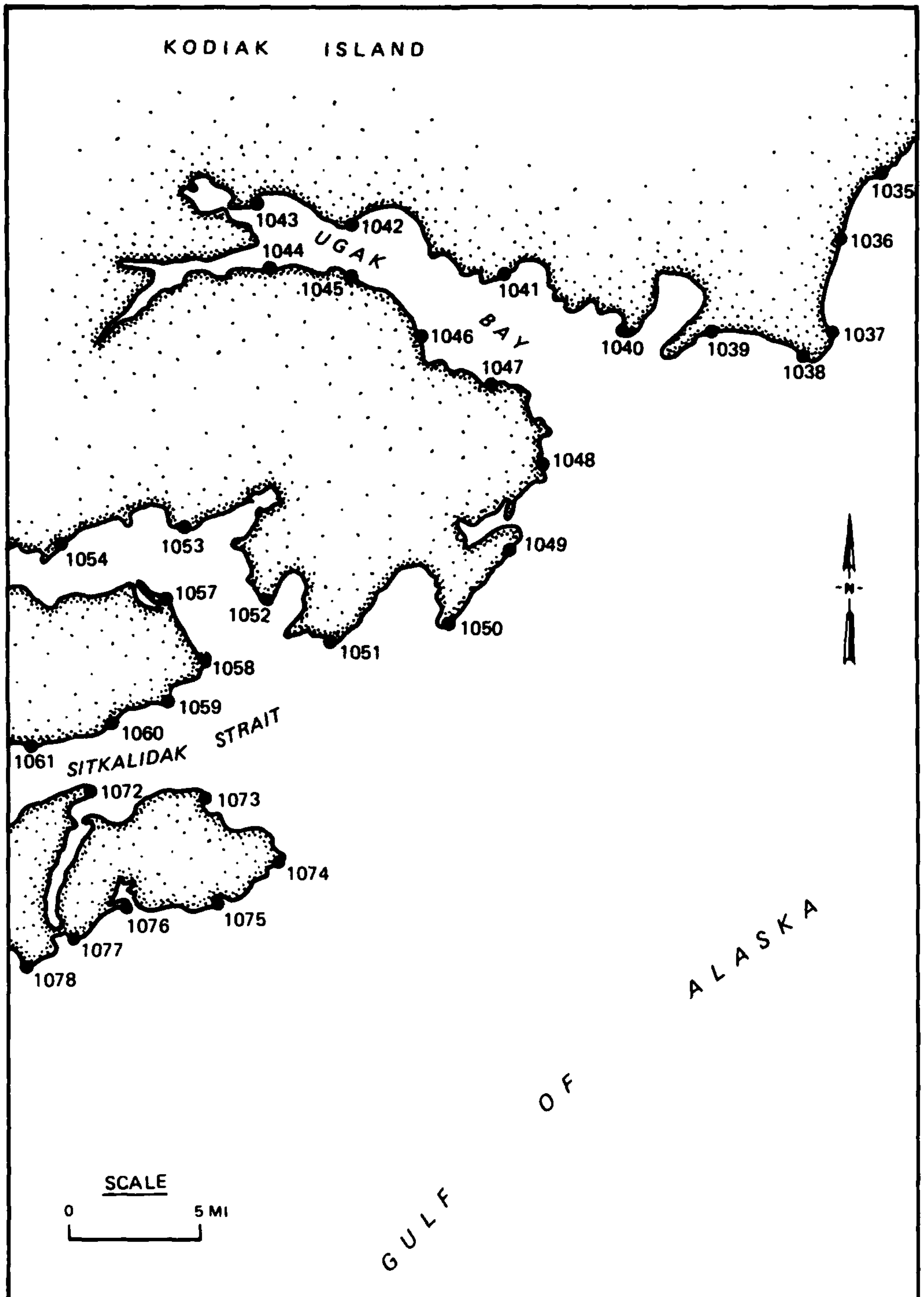
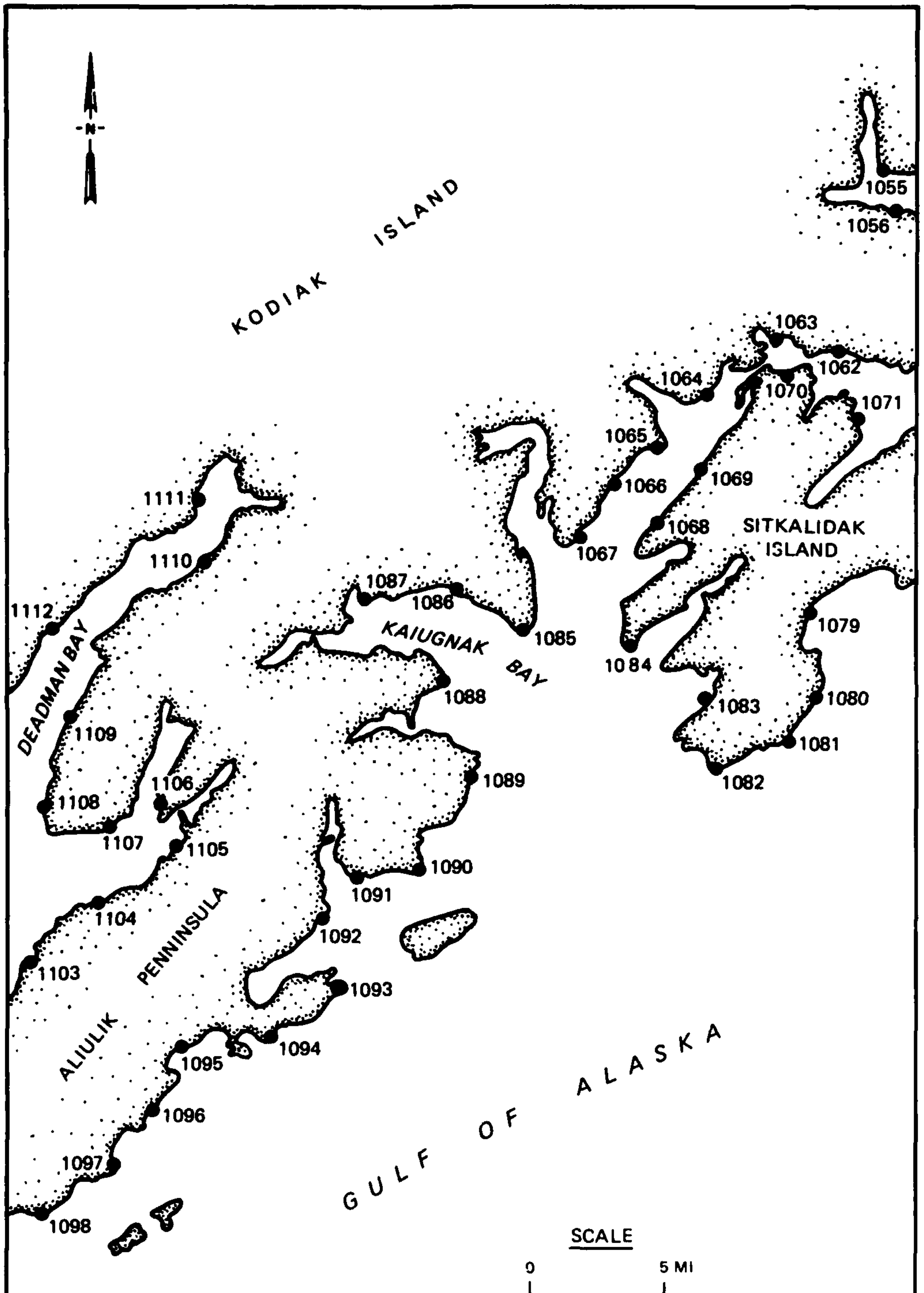

SCALE
0
5 MI
N
SHELIKOF STRAIT
TANAAK CAPE
AFOGNAK ISLAND
RASPBERRY ISLAND
VIEKODA BAY
WHALE ISLAND
KODIAK ISLAND
1234
1233
1232
1231
1230
1229
1228
1227
1226
1225
1224
1223
1222
1221
1220
1219
1218
1217
1216
1215
1214
1213
1212
1211
1210
1209
1208
1207
1206
1205
1204
1014
1015
1016
1017
1018
1019
1020
1021
GAGES 1014 - 1021 AND 1204 - 1234

PLATE 72



GAGES 1035 - 1054, 1057 - 1061, AND 1072 - 1078

PLATE 73



GAGES 1055 - 1056, 1062 - 1071, 1079 - 1098, AND 1103 - 1112

PLATE 74

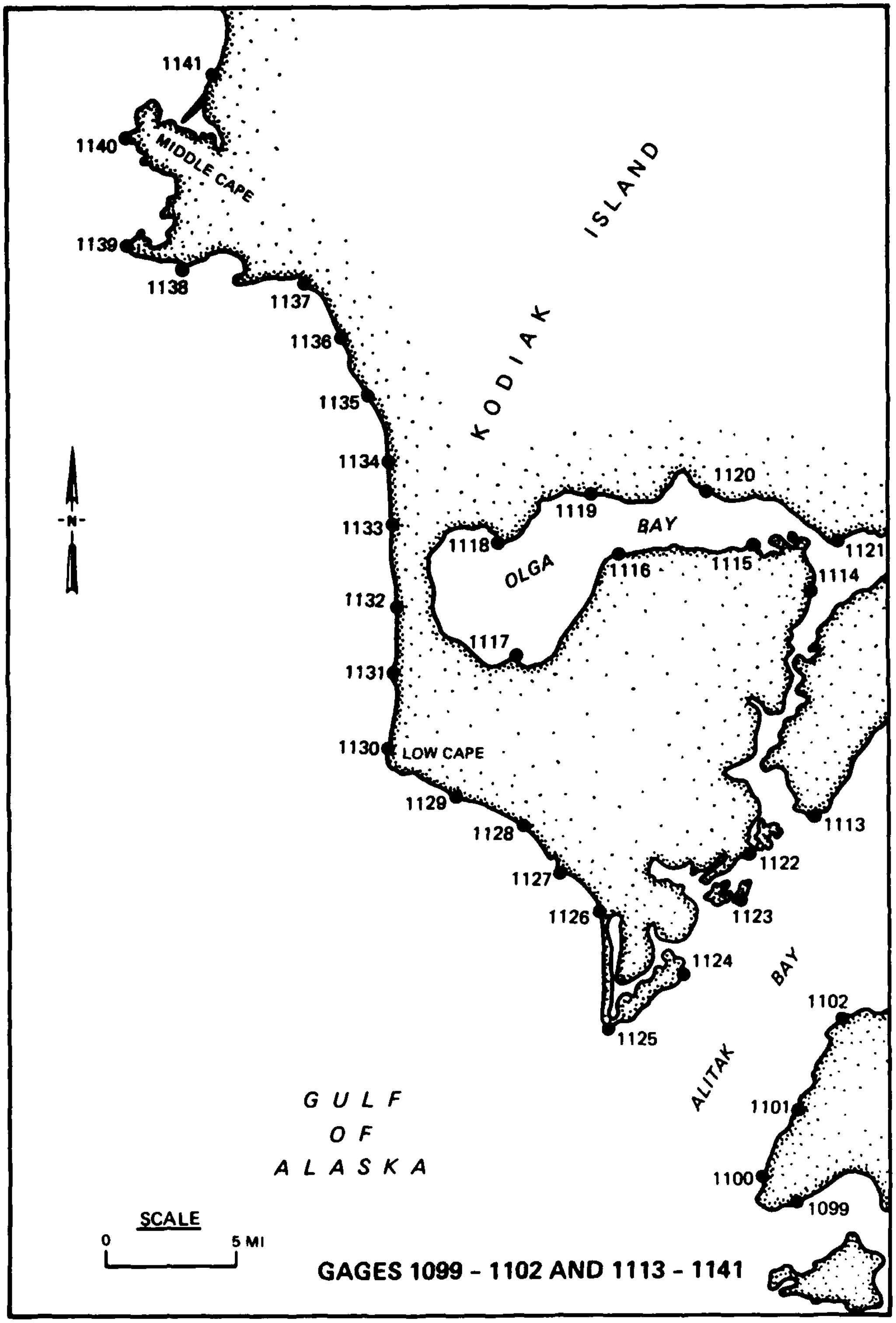

1141
1140
MIDDLE CAPE
1139
1138
1137
1136
1135
1134
1133
1132
1131
1130
LOW CAPE
1129
1128
1127
1126
1125
1124
1123
1122
1113
1114
1115
1116
1117
1118
1119
1120
1121
OLGA
BAY
KODIAK
ISLAND
ALITAK
BAY
1102
1101
1100
1099
GULF
OF
ALASKA
N
SCALE
0
5 MI
GAGES 1099 - 1102 AND 1113 - 1141

PLATE 75

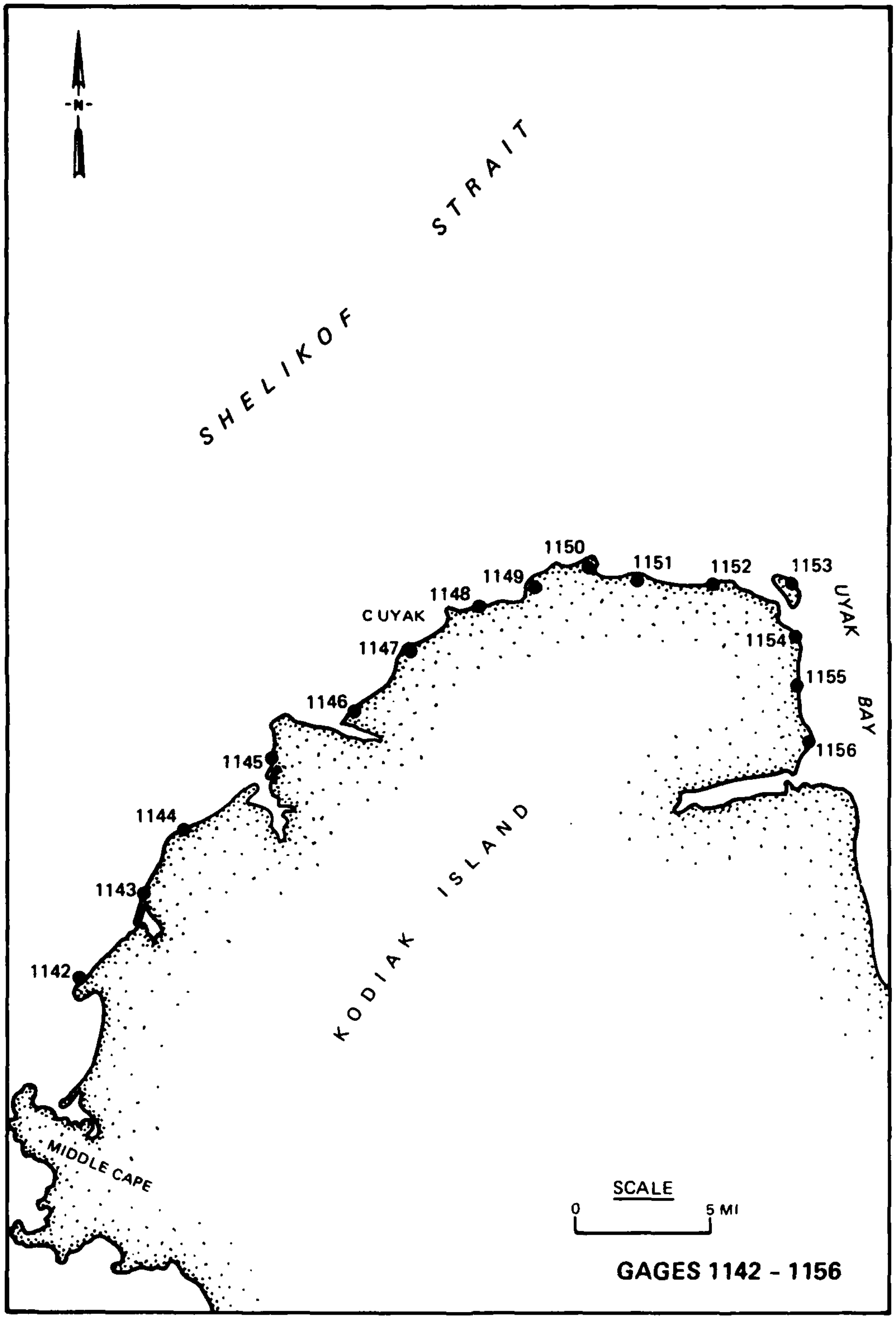

N
SHELIKOF STRAIT
KODIAK ISLAND
UYAK BAY
CUYAK
MIDDLE CAPE
1142
1143
1144
1145
1146
1147
1148
1149
1150
1151
1152
1153
1154
1155
1156
SCALE
0
5 MI
GAGES 1142 - 1156

PLATE 76

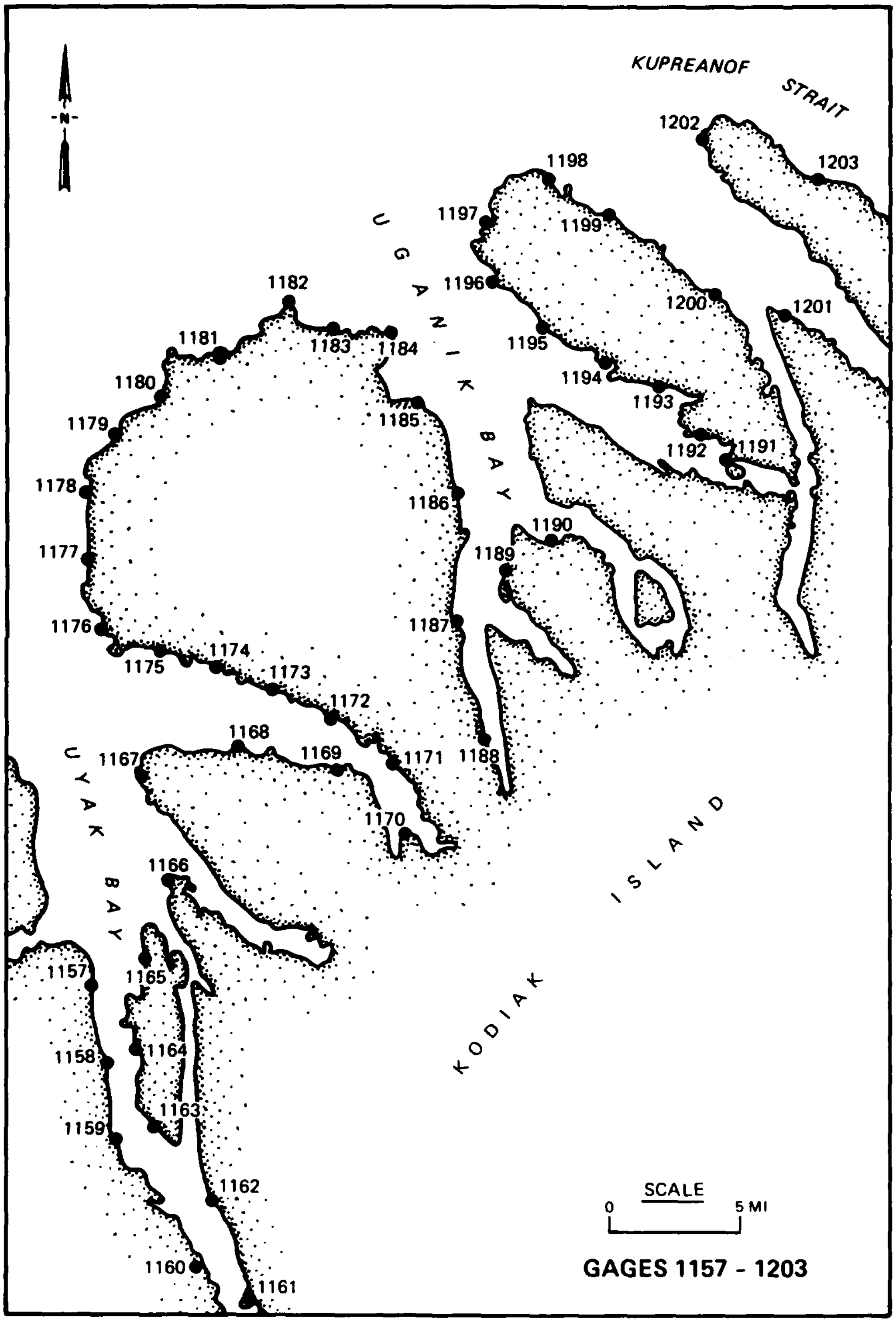

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PLATE 77

APPENDIX A: NOTATION

a	Length of major axis of elliptical rupture zone
b	Length of minor axis of elliptical rupture zone
d	Still-water depth
f	Coriolis parameter
g	Acceleration due to gravity
H_a	Wave height in direction of major axis of ellipse
H_{avg}	Average runup over a coast, m
H_b	Wave height in direction of minor axis of ellipse
i	Tsunami intensity
k	Linear friction coefficient
$n(\ )$	Tsunami probability function
R	Earth's radius
t	Time
u	Depth-averaged velocity in the θ-direction
v	Depth-averaged velocity in the ϕ-direction
η	Displacement of water surface from still-water level
θ	Latitude measured from zero at the North Pole
ϕ	Longitude measured east from Greenwich

END

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